The Impact of Inequity Aversion on Relational Incentive Contracts

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Abstract

This thesis consists of three self-contained essays that investigate the impact of fairness concerns among agents on the efficient design of real-world incentive contracts used to mitigate moral-hazard problems under non-verifiable performance. All papers consider situations in which a firm employs two inequity averse workers whose individual performances are, albeit observable by the contracting parties, not contractible.

The first paper studies the effects of inequity aversion on relational employment contracts. Performance is evaluated via an agent's individual non-verifiable contribution to firm value. In contrast to the literature, we find that inequity aversion may be beneficial: In the presence of envy, for a certain range of interest rates relational contracts may be more profitable. For some interest rates reputational equilibria exist only with envious agents.

In the second paper, I compare group to individual performance pay. Avoiding payoff inequity, the group bonus contract is superior as long as the firm faces no credibility problem. The individual bonus contract may, however, become superior albeit introducing the prospect of unequal pay. This is due to two reasons: The group bonus scheme is subject to a free-rider problem requiring a higher incentive pay and impeding credibility of the firm. Moreover, with individual bonuses the firm benefits from the incentive-strengthening effect of envy, allowing for yet smaller incentive pay and further softening the credibility constraint.

The third paper contrasts a rank-order tournament with independent bonus contracts. Whereas the bonus scheme must be self-enforcing, the tournament is contractible. Yet the former incentive regime outperforms the latter as long as credibility problems are not too severe. This is due the fact that the tournament requires unequal pay across peers with certainty and thus imposes large inequity premium costs on the firm. For a simple example, I show that the more envious the agents are the larger is the range of interest rates for which the bonus scheme dominates the tournament.

Keywords:
Principal-Agent, Relational Contracts, Bonus Contracts, Tournaments, Team, Inequity Aversion, Envy

Zusammenfassung

Diese Dissertation enthält drei Aufsätze zur Theorie der Anreizsetzung bei nichtverifizierbaren Leistungsmaßen. Untersuchungsgegenstand sind die Auswirkungen individueller Fairnesspräferenzen auf die Ausgestaltung und Eignung verschiedener Anreizmechanismen, welche in realen wirtschaftlichen Situationen Anwendung finden. Alle Arbeiten analysieren Umgebungen moralischen Risikos, in denen eine Firma zwei ungerechtigkeitsaverse Mitarbeiter beschäftigt, deren individuelle Arbeitsleistung zwar durch die Vertragsparteien beobachtbar, jedoch nicht kontrahierbar ist.

Der erste Aufsatz untersucht die Effekte von Ungerechtigkeitsaversion auf relationale Anreizverträge. Als Leistungsmaß eines Agenten dient sein individueller Beitrag zum Firmenwert. Abweichend von der Literatur zeigt sich, dass Ungerechtigkeitsaversion vorteilhaft sein kann: Für bestimmte Zinssätze können relationale Verträge mit neidischen Agenten profitabler sein, wenn sie nicht sogar nur mit solchen implementierbar sind.

Der zweite Aufsatz vergleicht relationale Individual- und Gruppenbonusverträge. Durch das Vermeiden ungleicher Löhne sind letztere profitabler, solange sich die Firma keinem Glaubwürdigkeitsproblem gegenübersieht. Dies kann sich jedoch umkehren, da Individualboni vergleichsweise kleiner sind und somit die Selbstdurchsetzung des Vertrags fördern. Ursachen dafür sind das Vermeiden des Trittbrettfahrerproblems und der anreizverstärkende Effekt von Neid im Individualschema.

Im dritten Aufsatz wird relationalen Individualbonusverträgen ein relatives Leistungsturnier gegenübergestellt. Im Gegensatz zum Bonusvertrag unterliegt das Turnier keiner Glaubwürdigkeitsbeschränkung. Dennoch ist ersteres Anreizschema profitabler, solange das Glaubwürdigkeitsproblem der Firma nicht zu groß ist. Dies liegt an der zwingenden Auszahlung ungleicher Löhne im Turnier und den daraus resultierenden hohen Kosten für Ungleichheitsprämien. Weiter wird für ein Beispiel gezeigt, dass die Zinsspanne, für die der Bonusvertrag das Turnier dominiert, im Neid der Agenten steigt.

Schlagwörter:
Prinzipal-Agent, Relationale Verträge, Bonusverträge, Relative Leistungsturniere, Team, Ungleichheitsaversion, Neid

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Chapter 1

Introduction

> *"Implicit contracts can be effective only in a social atmosphere that incorporates a sense of mutual respect and a consensus on principles of fair play and good faith."*
>
> ARTHUR M. OKUN[1]

Organizations are an inherent part of the economic landscape. Their very existence is, however, difficult to justify in the classical theory of general equilibrium since the price mechanism is expected to govern all transactions in the economy. Moreover, that theory does not account for another essential aspect of economic interaction: Most economic relationships are characterized by asymmetries of information. For instance, costumers know more about their tastes than firms, a monopolist is better informed about his costs than the regulating agency, job applicants know more about their abilities than employers, and all economic agents undertake actions that are at least partly unobservable. Rational agents can then be expected to try to take advantage of their private information. In recognition of the foregoing, in the 1970s, the theory of contracts evolved to study the complexity of strategic interactions between privately informed agents in well-defined institutional settings. Focusing on necessarily partial equilibrium models, that theory makes intensive use of game-theoretic tools. In particular, the models take into account the constraints imposed by the prevailing institutional environment through a contract.[2]

[1]Okun (1980), p. 8.

[2]For this paragraph, compare Salanié (2005), pp. 1-3. The theory of contracts is more generally called the ‘economics of information’. For surveys see also Laffont and Martimort (2002) or Bolton and Dewatripont (2005).

The most prominent class of models adopts the principal-agent paradigm. A principal-agent relationship arises whenever one individual depends on the action of another. The informed party taking the action is referred to as the agent whereas the affected, uninformed party is called the principal.[3] Usually, the objectives of the two parties will not coincide; by contrast, in most economic relationships they will differ significantly. As a result, the agent has an incentive to behave in his own rather than the principal's interest. The thereof resulting principal-agent problems are commonly categorized by the type of private information, i.e. 'hidden action' or 'hidden information', and by the time when the information asymmetry arises, i.e. before or after the conclusion of a contract.[4] The present thesis is concerned with one major class of problems that arise ex post because the principal cannot perfectly monitor the agent's action. In such situations fundamental incentive problems emerge which are referred to as moral hazard.[5]

It is difficult to imagine any economic relationship that is not subject to moral hazard. Examples are omnipresent; the relations between insurers and insurees, shareholders and managers, car-owners and mechanics, or patients and doctors.[6] Being also prevalent in employment relationships, moral hazard is the cause of widespread motivation problems in firms. However, even if the agent's effort is unknown to the principal, she usually observes some performance signals correlated to the effort undertaken.[7] In case these performance measures are verifiable by a court, an appropriately designed incentive contract can help to align the agent's objective with that of the principal by rewarding favorable performance.[8] For instance, such incentive schemes include bonus payments, piece rates, efficiency wages, or stock options.

[3]Compare Pratt and Zeckhauser (1985), p. 2. For convenience, throughout the thesis, I will use the feminine pronoun for the principal and the masculine for the agent.

[4]Most principal-agent models greatly simplify the analysis by allocating all bargaining power to one of the parties, mostly the principal. The latter proposes a 'take-it-or-leave-it'-offer, and the agent just accepts or rejects the contract.

[5]The term originates from the insurance industry: An insuree does not bear the full consequences of his actions and therefore has a tendency to act less carefully than he otherwise would. One of the first and most striking empirical studies of moral hazard is Peltzman (1975), who investigates the effects of automobile safety regulations on driving behavior.

[6]Compare e.g. Salanié (2005), p. 120 or Bolton and Dewatripont (2005), p. 21.

[7]The term 'effort' should be interpreted generously. It is commonly used to designate the agent's whatsoever unobservable valuable input in the production process.

[8]Alternativley, the principal can punish undesirable performance. By now, there is a vast literature on optimal contracting under moral hazard and verifiable performance. Seminal papers include Arrow (1970), Holmström (1979), Grossman and Hart (1983), Sappington (1983), and Mirrlees (1999). For an overview see e.g. Prendergast (1999) and the numerous therein. For a comprehensive overview of the economic theory of incentives see Gibbons (2005).

The extent to which incentive contracts indeed mitigate the moral hazard problem fundamentally depends on the suitability of the underlying performance signals. Consequently, the problem of efficient performance measurement is central to principal-agent theory.[9] An 'ideal' performance measure would perfectly reflect an agent's contribution to firm value. The contract would then specify a wage paid only if the agent chooses the most efficient action. As Milgrom and Roberts (1992) note, [*u*]*nfortunately, perfect connections between unobservable actions and observed resulting outcomes are rare. More often people's behavior only partially determines outcomes, and it is impossible to isolate the effect of their behavior precisely.*[10] Thus, available performance measures are usually imperfect since they are affected by measurement errors, individual luck, or other random factors. Moreover, since it is usually more difficult for the agents to diversify risk than for the firm, the former are often assumed to exhibit risk aversion. This leads to the well-known trade-off between risk sharing and incentives.[11]

The present thesis, however, deals with another important feature of performance measures that affects the feasibility and quality of incentive provision. In particular, an employee's job typically involves several eventually yet conflicting dimensions such as the production of sufficient quantity, the provision of good quality, the cooperation in a team, or the supervision of other workers. Consequently, an agent's contribution to firm value is often too complex and subtle to be verified by a third party, e.g. a court.[12] If not impossible, it will in general be too costly to credibly communicate each piece of information that is available to the principal to an outside party. In many cases, the principal will yet be able to subjectively assess the agent's overall performance.[13] Though such non-verifiable performance assessments provide valuable information on the agent's effort, they cannot be part of a court-enforceable (or explicit) incentive contract.

Employment relationships are, however, usually long-term. Then non-verifiable performance measures can be used for the provision of incentives in so-called relational (or implicit) contracts, which exhibit realistic features of real-world incentive schemes. Such contracts are sustained by the value of future relationships and must be self-enforcing; they may exist in repeated principal-agent relationships as reputational

[9] See e.g. Kerr (1975), Holmström and Milgrom (1991), or Baker (2002).

[10] Milgrom and Roberts (1992), p. 187.

[11] This problem has been extensively discussed in the literature. See e.g. Prendergast (1999) and the numerous references therein.

[12] Compare Baker, Gibbons, and Murphy (1994), p. 5.

[13] Given that verifiable measures of performance exist, subjective (non-verifiable) assessments may complement or improve on the available objective measures. See e.g. Baker et al. (1994).

equilibria. Specifically, reputation concerns have to restrain the parties from reneging on the agreement.[14] Important papers on self-enforcing contracts under moral hazard include Baker, Gibbons, and Murphy (1994, 2002) and Levin (2003). Moreover, some papers compare the efficiency of different incentive regimes for multiple agents in a dynamic setting, see e.g. Che and Yoo (2001) or Kvaløy and Olsen (2006, 2007).

Another possibility to incentivize the workers, when performance measures are non-verifiable, is the use of rank-order tournaments. These are highly competitive incentive schemes based upon relative performance. They are thus applicable in firms where several workers perform similar tasks. Tournaments have been extensively discussed in the literature since the seminal articles by Lazear and Rosen (1981) and Green and Stokey (1983).[15] In particular, Malcomson (1986) emphasizes that *rank-order contracts remain incentive compatible even when information about agents' performance is known only to the principal because the total payment from the principal to all agents taken together is independent of the outcome that occurs.*[16] This is due to the fact that the principal credibly commits to a fixed prize structure ex ante. As a result, she cannot save wage costs by understating the agents' performance ex post. In contrast to other incentive schemes, tournaments are thus contractible in situations where performance is non-verifiable.

Traditional economic models, including the aforementioned papers, assume that all people's motivation is driven by pure self-interest. Individual employment relationships are, however, typically embedded in the larger framework of the firm, thus in a social context where individual comparison may play a role. Numerous studies suggest that individuals deviate from pure selfish behavior in various situations, suggesting that they have other-regarding preferences.[17] Fehr and Schmidt (2000) note that [*e*]*xamining contractual choices and behavioral responses to different incentives schemes under the pure self-interest assumption is an important first step.* [...] *However, in view of the*

[14]See e.g. the seminal papers by Holmström (1981) and Bull (1987). Early contributions on relational contracts have focused on environments with symmetric information, see also MacLeod and Malcomson (1989) and Levin (2002).

[15]See e.g. Nalebuff and Stiglitz (1983), Malcomson (1984, 1986), O'Keeffe, Viscusi, and Zeckhauser (1984), or Bhattacharya and Guasch (1988).

[16]Malcomson (1986), p. 807.

[17]See e.g. Berg, Dickhaut, and McCabe (1995), Fehr, Kirchsteiger, and Riedl (1998), Fehr, Gächter, and Kirchsteiger (1997), or Fehr, Klein, and Schmidt (2001). For an overview of the experimental literature on other-regarding preferences see Camerer (2003) or Fehr and Schmidt (2006). In psychology and sociology, there is a long tradition dealing with social preferences, see e.g. Goranson and Berkowitz (1966), Thibaut and Kelley (1959), and Austin (1977). For a comprehensive overview of the intersections in psychology and economics see Rabin (1998) and the manifold references therein.

accumulating evidence that a non-negligible fraction of the population exhibits reciprocally fair behavior, it is time to take this into account.[18] In the last decade, economists have increasingly recognized the relevance of other-regarding preferences. By now, it is widely acknowledged, that individuals seem to be concerned with aspects such as fairness and reciprocity, and that their own utility is affected by the payoffs of others in their peer group. Depending on the perceived quality of the relationship with their reference group, individuals apparently behave more or less fair and exhibit envy, empathy, or spitefulness.[19] Hence, it is important to recognize that the principal's decisions regarding one worker might also affect other employment relationships within the same organization.

Alternative approaches regarding the formalization of other-regarding preferences have been proposed by e.g. Rabin (1993), Fehr and Schmidt (1999), Bolton and Ockenfels (2000), and Falk and Fischbacher (2006). Moreover, there is a growing literature linking standard incentive theory and social preferences. A notable class of models adopts the approach by Fehr and Schmidt (1999), assuming that the individuals exhibit 'self-centered inequity aversion'. In particular, workers are inequity averse when they dislike inequitable payoff distributions. Much of the work is associated with the impact of inequity aversion on individual incentive contracts under verifiable performance. Moreover, the majority of papers focuses on mutually inequity averse agents, e.g. Demougin, Fluet, and Helm (2006), Bartling and von Siemens (2007), and Neilson and Stowe (2008).[20] The effects of such preferences on tournaments are analyzed by Demougin and Fluet (2003) and Grund and Sliwka (2005). Other papers compare the efficiency of different incentive regimes when workers are concerned with relative payoffs, e.g. Itoh (2004), Demougin and Fluet (2006), Goel and Thakor (2006), and Bartling and von Siemens (2007), Rey-Biel (2008). An important insight of the foregoing literature is that the prospect of unequal payoffs between peers implies additional agency costs for the firm, the so-called inequity premium.[21]

Furthermore, in the existing literature, it is frequently argued that concerns for equity or fairness could serve as an explanation for observed wage compressions or the

[18]Fehr and Schmidt (2000), p. 1067.

[19]See e.g. Loewenstein, Thompson, and Bazerman (1989) for the importance of reference groups.

[20]Englmaier and Wambach (2005) and Dur and Glazer (2008) examine incentive contracts when agents care about inequality relative to the principal.

[21]An exception may be the case in which workers earn rents. See Demougin and Fluet (2003), Demougin and Fluet (2006), and Bartling and von Siemens (2007).

absence of individual performance pay.[22] In particular, incentive schemes conditioning upon joint-performance evaluation such as group compensation schemes rule out the possibility of unequal payoffs across workers. Restricting the analysis to verifiable performance measures, recent theoretical studies show that inequity averse preferences among agents may indeed render team incentives optimal (see Englmaier and Wambach, 2005; Goel and Thakor, 2006; Bartling, 2008).

The purpose of the present thesis is the identification of advantages and drawbacks of real-world incentive schemes given that the agents' individual performance measures are not verifiable and their preferences are characterized by inequity aversion. By extending the analysis to non-verifiable performance measures, the study thus reexamines the conclusions regarding the impact of inequity aversion drawn in the existing literature on incentive contracts. At the same time, the thesis reconsiders the results of the literature on relational contracts by introducing fairness concerns among agents. Altogether, this research offers a complementary, preference-dependent explanation for the suitability or inferiority of various real-world incentive regimes in repeated employment relationships. Specifically, my results suggest that the agents' specific preference structure has non-negligible implications for the efficient design of incentive contracts. Moreover, the impact of other-regarding preferences proves to be sensitive to the verifiability of the underlying performance measures. Altogether, in contrast to the existing literature, my findings underline that inequity aversion may be beneficial with regard to the mitigation of moral-hazard problems.

In the given research context, three specific incentive regimes exhibit particularly relevant characteristics: individual, joint, and relative performance-pay schemes. In particular, I analyze and compare individual bonus contracts, group bonus contracts, and rank-order tournaments. The first incentive regime involves agency costs of two kinds; those due to inequity aversion and those stemming from credibility problems. By contrast, group bonus schemes and tournaments bring forth only one of these problems, respectively. Though a group bonus scheme excludes the possibility of unequal pay completely, I find that it amplifies the credibility problem due to large bonus payments. At the other extreme, rank-order tournaments avoid credibility problems altogether. Yet, this comes at the cost of a large inequity premium. The present thesis is composed of three self-contained studies that deal with the trade-offs arising from the aforementioned features of the three incentive schemes. Specifically, I analyze the

[22]See e.g. Baker, Jensen, and Murphy (1988). In a survey study, Bewley (1999) finds that internal pay structures aim at providing internal pay equity.

profitabilities of the respective contracts given that agents are inequity averse, and, moreover, investigate the impact of a variation in the agents' propensity for inequity aversion on the contracts. In the remainder of this introduction, I summarize the results of each paper.

In all three papers, I consider a repeated moral-hazard situation in which a firm employs two inequity averse workers who perform an identical task. The principal observes for each agent an imperfect non-verifiable performance measure of the effort undertaken. In the first paper, which is joint work with Julia Schmid, we analyze an individual bonus scheme where the firm offers each agent a reward for favorable individual performance. Under such a contract, payoff inequity arises with some positive probability though in equilibrium workers exert the same effort. In order to guarantee self-enforcement of the incentive scheme, the principal must be credible to keep her promise regarding the agreed terms of payments. In particular, this requires that her gains from reneging, i.e. the bonus, fall short of the discounted gains from continuing the relational contract.

We find that this credibility constraint is ambiguously affected by the presence of inequity aversion: On the one hand, inequity aversion has a positive incentive effect. This lowers the principal's temptation to renege on the bonus payments and, consequently, facilitates her credibility. On the other hand, the principal must pay the agents an inequity premium in order to compensate them for the disutility from expected payoff inequity. This reduces the principal's long-run profits from the contract, and credibility becomes more difficult. Altogether, whenever the reduction of the bonus payments exceeds the loss of future profits, inequity aversion softens the principal's credibility constraint. We find that there are combinations of inequity aversion and discount rates for which relational contracts are more profitable than relational contracts with purely selfish agents. In that case, inequity aversion becomes an advantageous factor in principal-agent relationships in the sense that reputational equilibria can be sustained for a larger range of interest rates.

In the second paper, I compare group incentives to individual performance pay. The principal offers the agents a bonus contract contingent upon either individual performance or an aggregated measure of both workers' individual performances. I find that, avoiding payoff inequity altogether, the group bonus contract implements first-best effort and is thus superior as long as the firm faces no credibility problem. Once the firm's discount rate is sufficiently small, however, the group bonus that implements first-best efforts induces the firm to renege on its promise. Credibility then requires reducing the group bonus thereby inducing non-optimal effort levels which lead to smaller profits. In comparison, the individual bonus provides two benefits. First, a group bonus introduces a free-rider problem. Hence, it must be larger than the respective individual bonus for implementing a given level of effort. Second, using a group bonus, the firm cannot exploit the incentive-strengthening effect of inequity aversion which allows for lowering the bonus level under individual performance pay. Both of these features facilitate credible commitment in the individual bonus contract. Accordingly, there are combinations of inequity aversion and discount rates for which the relational individual bonus contract is more profitable than the group bonus contract. Moreover, there are cases where the group contract is yet infeasible whereas the individual bonus contract still yields positive profits.

In the third paper, I contrast individual bonus contracts with rank-order tournaments. In the tournament, the agent with the best performance is awarded a winner prize whereas the other receives the smaller loser prize. Under the bonus contract, an agent obtains a bonus if his performance meets or exceeds an ex ante specified standard. Whereas the latter incentive scheme must again be self-enforcing, the tournament is contractible. Yet I find that the bonus regime outperforms the tournament for a range of sufficiently small interest rates. This is due to the fact that the latter contract necessarily confronts the contestants with the certainty of unequal payoffs, which imposes large inequity premium costs on the firm. By contrast, the bonus scheme entails less expected payoff inequity. This renders the individual incentive regime superior as long as credibility problems are not too severe. For sufficiently large interest rates, however, credibility requirements restrict the set of implementable effort levels thereby reducing profits. Thus, the firm switches to the tournament contract once the interest rate is such that profits under both schemes coincide. Moreover, for a simple example, I show that the more inequity averse the agents are, the larger is the range of interest rates for which the bonus scheme dominates the tournament.

Chapter 2

The Impact of Envy on Relational Employment Contracts

with Julia Schmid

We study the effects of envy on relational employment contracts in a standard moral hazard setup with two agents. Performance is evaluated via an observable, but non-contractible signal which reflects an agent's individual contribution to firm value. Both agents exhibit horizontal disadvantageous inequity aversion. In contrast to the literature, we find that inequity aversion may be beneficial: In the presence of envy, for a certain range of interest rates relational contracts may be more profitable. For some interest rates reputational equilibria exist only with envious agents.

2.1 Introduction

The present paper investigates how concerns for fairness among agents affect the optimal provision of incentives in a one-task framework with only subjective performance measures. In particular, we analyze the impact of horizontal disadvantageous inequity aversion on the principal's credibility in a relational contract. So far the literature has focused on the impact of inequity aversion on the design of explicit incentive contracts. In these environments, employing inequity averse agents comes at a cost for the principal. In contrast to that, we find that with implicit incentives the principal might prefer to employ inequity averse rather than inequity neutral agents.

Frequently, if not typically, the agent's true contribution to firm value cannot be objectively assessed. In many cases, his contribution can, nonetheless, be observed by both contracting parties. The observed subjective performance may be used in implicit agreements (relational contracts). As subjective assessments are not verifiable by third parties, contracts are not court-enforceable and, thus, have to be self-enforcing. They may be implemented in long-term relationships as reputational equilibria.[1]

So far the literature on relational contracts has primarily focused on problems under symmetric information.[2] Apart from that there is an evolving literature analyzing self-enforcing contracts under asymmetric information, in particular moral hazard in effort (Baker et al., 1994, 2002; Levin, 2003; Kvaløy and Olsen, 2006; Schöttner, 2008). We contribute to the latter strand of literature by analyzing fairness concerns that may arise in multilateral contracting under ex-post asymmetric information.

As the agents' contributions to firm value are not necessarily perfectly correlated to their efforts, agents undertaking the same effort could receive different rewards. This might provoke envy, empathy or spiteful behavior among agents, especially if they work on similar tasks.[3] Taking into account the presence of envy among agents, we investigate the feasibility and profitability of relational contracts.

We consider an employment relationship between one principal and two risk-neutral, not financially constrained agents who exhibit disadvantageous inequity aversion. We have in mind employees working on similar tasks in small or medium-size firms or divisions where workers tend to compare their payoffs with those of their colleagues.[4] Specifically, we model preferences as 'self-centered inequity aversion', as proposed by Fehr and Schmidt (1999), abstracting from empathy.[5] Neither agent's effort is directly observable by the principal, albeit imperfectly correlated with individual performance. The principal seeks to mitigate the resulting moral hazard problem by offering each agent an incentive contract contingent on their respective performances. As observed performance is not verifiable, the contract has to be self-enforcing, i.e. reputation concerns have to restrain the principal from deviating from the incentive contract.

[1]Reputational equilibria may exist if one party cares about her reputation in future relationships. See e.g. Holmström (1981) or Baker, Gibbons, and Murphy (2002).

[2]See e.g. Bull (1987), MacLeod and Malcomson (1989), and Levin (2002).

[3]For experimental evidence of other-regarding preferences see e.g. Goranson and Berkowitz (1966), Berg et al. (1995), Fehr et al. (1998), and Fehr et al. (1997).

[4]For the importance of reference groups, see e.g. Loewenstein et al. (1989). Of course, an individual's perception of fairness could also include the principal (vertical inequity aversion). However, we are rather interested in inequity averse preferences among agents and the effects thereof for the optimality of employment schemes in the firm.

[5]For alternative approaches regarding the formalization of fairness concerns see e.g. Rabin (1993), Bolton and Ockenfels (2000), and Falk and Fischbacher (2006).

It is well known that, with explicit incentives, more envious agents exert more effort than less envious ones, when being offered identical incentive contracts (Grund and Sliwka, 2005; Demougin and Fluet, 2006). However, to ensure participation, the principal has to pay the inequity averse agents a premium to compensate them for the faced risk of unequal payoffs (inequity premium). In this kind of framework, agency costs increase in the presence of inequity aversion, as reported by e.g. Bartling and von Siemens (2007) and Grund and Sliwka (2005).[6] Both results are true for our model as long as only one period is considered. Here, the principal would rather employ inequity neutral than inequity averse agents.

The present paper analyzes how this conclusion is affected under a relational contract. The principal's credibility constraint requires that her gains from reneging fall short of the discounted gains from continuing the relational contract. We find that this constraint is ambiguously affected by the presence of envy: On the one hand, the incentive for the principal to deviate from the relational contract in order to save bonus expenses decreases in the propensity for envy. Intuitively, this is due to the fact that envious agents work harder given the same incentive in order to avoid ending up with a lower payoff than their colleagues. This facilitates credible commitment on the principal's side. On the other hand, as agents have to be compensated for their disutility incurred by envy, the principal's long-run profits out of the contract decrease as agents become more envious. Consequently, commitment to paying the offered bonus is more difficult.

The sum of these two counteracting effects determines whether credibility is either more or less easily obtained by the principal as agents become more envious. Whenever the savings due to lower bonus payments exceed the loss of future profits via the inequity premium payments, the principal prefers to employ more envious agents.

We identify a necessary and sufficient condition under which, for a range of the principal's discount rate, relational contracts are less profitable or even infeasible when agents do not exhibit any disadvantageous inequity aversion. In that case, envy becomes an advantageous factor in principal-agent relationships in the sense that it softens the principal's credibility constraint and more reputational equilibria can be sustained with envious agents.

[6]This holds under unlimited liability which is the case we consider. Under limited liability, this might not be true; wage costs may decrease under inequity aversion as long as agents receive rents. See e.g. Demougin and Fluet (2003, 2006).

Our findings underline that empirically observed cultural differences in social preferences should not be neglected in organizational decisions when firms rely on implicit incentives. In particular, the implementation of relational employment contracts might not be possible with inequity neutral agents, if the principal's discount rate is relatively low. Moreover, relational contracts might be more profitable in countries where people generally exhibit a greater degree of inequity aversion due to cultural differences. For example, Alesina, Di Tella, and MacCulloch (2004) and Corneo (2001) find Europeans to exhibit a higher propensity for inequity aversion in comparison to U.S. Americans.[7]

Thus, the implementation of relational contracts might be more frequent in countries whose populations are more sensitive to inequity aversion. Taking cultural differences in the degree of inequity aversion into consideration, our findings support the empirical analysis by Moriguchi (2005). She argues that relational contracts are more prevalent in Japan than in the United States pointing out that the United States were hit harder by the Great Depression compared to Japan. This goes along with lower continuation profits and thus results in the less frequent use of relational contracts in the United States. According to our analysis, a depreciation of future profits may have a less severe impact on the feasibility of relational contracts if employees are more strongly inequity averse. Hence, these countries' differences in the propensity for inequity aversion could also play a role for the explanation of differences in institutional arrangements in this context.

Before proceeding with the analysis, two caveat are in order. First, our main analysis focuses on individual bonus schemes. However, other contracts as for example peer-dependent compensation schemes might be possible. We discuss the benefits and drawbacks of rank-order tournaments and team bonus contracts within our setting in a supplemental section, and relate the findings to the results for the individual bonus scheme.

Second, one has to be aware of the fact that for an individual's perception of fairness and equity, many determinants beside the colleague's payoff may play a role; e.g. effort, ability, education, gender, status etc. Cognition of inequity is presumably affected by mutual comparisons regarding all the mentioned characteristics. In our model, due to the agents' homogeneity in both preferences and characteristics, differences in payoffs are the sole source of inequity. Hence, payoff inequality accords with inequity.

[7] For a recent empirical cross-country investigation of preferences for redistribution see Isaksson and Lindskog (2007). The study's findings suggest that Swedish, Hungarian, and German people are more supportive of redistribution than U.S. Americans.

The next section describes our basic framework. Subsection 2.2.1 addresses the agency problem in the single-period game. Subsection 2.2.2 develops the reputation game and thereby the relational contract. In section 2.3, we examine the impact of the agents' propensity for envy on the relational contracts and derive our main results concerning the principal's credibility problem. Section 2.4 discusses alternative compensation schemes. Section 2.5 concludes.

2.2 The Model

We consider a repeated game between a principal (the firm) and two agents who are homogeneous in preferences and characteristics.[8] In each period, agent i, $i = 1, 2$, chooses an unobservable effort level e_i that stochastically determines the agent's contribution to firm value Y_i. That contribution is either high or low; $Y_i \in \{0, 1\}$. It is observable by all three contracting parties but not verifiable, and can therefore only be used as a performance measure in a self-enforcing relational contract. By exerting effort agent i affects the probability of $Y_i = 1$:

$$\Pr[Y_i = 1|e_i] = p(e_i), \tag{2.1}$$

where $p(e_i) \in [0, 1)$, $p(0) = 0$, $p'(e_i) > 0$, and $p''(e_i) < 0$. Agents' outputs are stochastically independent.

The principal offers each agent an individual incentive contract consisting of a fixed wage w and a per-period bonus b to be paid if a favorable signal is detected in that respective period.[9] Provided that the principal keeps her promise, the bonus is paid whenever she observes $Y_i = 1$. Thus, an agent's net monetary payoff is

$$\pi_i - c(e_i) = w + bY_i - c(e_i), \tag{2.2}$$

where $c(e_i)$ denotes each agent's costs of effort with $c(0) = 0$, $c'(0) = 0$, $c'(e_i) > 0$ $\forall$ $e_i > 0$, and $c''(e_i) \geq 0$.

Following Fehr and Schmidt (1999), both agents exhibit inequity aversion. In particular, we assume them only to suffer from disadvantageous inequity, i.e. they dislike

[8] Equivalently, we could assume the principal to employ many agents and approach the problem from the perspective of one agent, all other agents forming his reference group.

[9] That is we consider payment schemes without memory.

outcomes where they are worse off than the respective other agent. Each agent observes the other agent's gross monetary payoff. All parties are risk neutral and not financially constrained. For simplicity, the agents' utilities are assumed to be linear in money. Agent i's utility is given by

$$U_i\left(\pi_i, \pi_j\right) = \pi_i - c(e_i) - \alpha \max\{\pi_j - \pi_i, 0\}, \quad i \neq j, \tag{2.3}$$

where $\alpha \geq 0$ denotes the agents' propensity for envy. The third term thus captures the disutility derived from being worse off than agent j.[10]

The timing of events within a period is as follows. At the beginning of the period, the principal offers each agent the above specified compensation contract. Second, the agents either accept the contract or reject it in favor of an alternative employment opportunity that provides utility U_0. Third, if the agents accept the contract, agents simultaneously choose respective effort levels e_i. Fourth, Y_i is realized and observed by all parties. Finally, the agents receive the explicit fixed wage, and if $Y_i = 1$ the principal decides whether or not to pay the implicit bonus.

2.2.1 The Single-Period Game

To derive the relational contract, we initially consider the single-period game where we assume performance to be objectively assessable, i.e. there is no credibility problem on the principal's side. Given that agent j exerts effort e_j, agent i's expected utility is

$$E[U_i|e_i, e_j] = w + p\left(e_i\right) b - c\left(e_i\right) - \alpha(1 - p\left(e_i\right))p\left(e_j\right) b, \quad i \neq j, \tag{2.4}$$

where the last term captures the expected disutility from disadvantageous inequity amounting to the difference in payoffs b. A symmetric Nash-equilibrium is characterized by

$$e = \arg\max_{\widehat{e}} E[U_i|\widehat{e}, e]. \tag{2.5}$$

[10]Abstracting from costs, Fehr and Schmidt (1999) propose the following utility function: $U_i = \pi_i - \alpha \max\{\pi_j - \pi_i, 0\} - \beta \max\{\pi_i - \pi_j, 0\}, \alpha > \beta \geq 0$. Incorporating empathy via the parameter β would not affect our results qualitatively. For a brief discussion of $\beta < 0$ see section 5. Moreover, Demougin and Fluet (2006) take costs into account when investigating inequity: $U_i = \pi_i - c\left(e_i\right) - \alpha \max\{\pi_j - c\left(e_j\right) - \pi_i + c\left(e_i\right), 0\}$. This would also not change our results. However, an inconvenient discontinuity at the symmetric Nash-equilibrium would be introduced.

In the appendix we verify that there exists a symmetric Nash-equilibrium which is also unique. In equilibrium, the first-order condition yields

$$p'(e)\,b - c'(e) + \alpha p'(e)\,p(e)\,b = 0. \tag{IC}$$

Thus, given that the agents exhibit disadvantageous inequity aversion and are faced with a contract with bonus b, they will undertake effort e, given that (IC) is satisfied at e. Implicitly this defines a function

$$b(e;\alpha) = \frac{c'(e)}{(1+\alpha p(e))\,p'(e)}. \tag{2.6}$$

Proposition 2.1 *Under an individual bonus scheme, with an increasing propensity for envy, the agents exert more effort for any given bonus.*

Proof. Applying the implicit-function theorem to (IC) yields

$$\frac{de}{d\alpha} = -\frac{p'(e)\,p(e)\,b}{p''(e)\,b\,(1+\alpha p(e)) - c''(e)} > 0. \tag{2.7}$$

■

Intuitively, as envious agents suffer from being worse off than their co-workers as opposed to non-envious agents, they exert relatively higher levels of effort in order to decrease the probability of not getting the bonus. This incentive-strengthening effect is in line with Demougin and Fluet (2006).[11] In the remainder of the paper, we will refer to it as the *incentive effect.*

The principal's profit per agent i is $V_b = (1-b)\,Y_i - w$. Hence, in the one-shot game, she sets b, w, and e to maximize expected profit per agent subject to participation and incentive compatibility constraints:

$$\max_{b,w,e} \quad (1-b)\,p(e) - w \tag{2.8}$$

$$\text{s.t.} \quad E[U_i|e] \geq U_0, \tag{PC}$$

$$bp'(e) - c'(e) + \alpha p'(e)\,p(e)\,b = 0 \tag{IC}$$

[11]In the context of tournaments, Grund and Sliwka (2005) and Demougin and Fluet (2003) report the same result. Kräkel (2008) identifies an incentive-strenghthening effect when emotions play a role in tournaments.

Since we assume unlimited liability, the participation constraint binds, leading to a zero rent for the agents in the optimal contract. In equilibrium, for each agent we have

$$w + p\,(e)\,b = c\,(e) + \alpha(1 - p\,(e))p\,(e)\,b + U_0. \tag{2.9}$$

The second term on the right-hand side in equation (2.9) is the inequity premium. Hence, expected wage costs per agent are equal to the sum of his costs of effort, his reservation utility, and the inequity premium. Substituting w and b in the principal's objective function by using (2.9) and (2.6), her problem simplifies to

$$\max_e \;\; V_b\,(e;\alpha) = p(e) - c\,(e) - \alpha p(e)\,(1 - p(e))\,\frac{c'\,(e)}{(1 + \alpha p\,(e))\,p'\,(e)} - U_0. \tag{2.10}$$

Let e^* denote the effort level that maximizes the principal's expected one-period profit $V_b\,(e;\alpha)$.

Proposition 2.2 *Suppose that performance is verifiable. Then under an individual bonus scheme,*
(i) the first-best solution is obtained if agents are not envious, $\alpha = 0$.
(ii) the first-best solution can never be obtained if agents exhibit a propensity for envy, $\alpha > 0$.
(iii) total agency costs increase as agents become more envious.

Proof. As for the first part of the claim (i), observe that with $\alpha = 0$, the principal's objective function (2.10) is

$$V_b\,(e;0) = p(e) - c\,(e) - U_{0.} \tag{2.11}$$

Optimization with respect to effort requires marginal productivity to equal marginal costs of effort such that the first-best effort level $e = e^{FB}$ is implemented. To prove (ii), with $\alpha > 0$, in problem (2.10) the derivative of the inequity premium, $\alpha p(e)\,(1 - p(e))\,c'\,(e) \cdot ((1 + \alpha p\,(e))\,p'\,(e))^{-1}$, with respect to effort is non-zero. Hence, profit-maximizing effort cannot be first-best. As to (iii), using the envelope theorem, observe that the derivative of (2.10) with respect to α is negative, as $-\frac{c'(e)}{p'(e)}\frac{p(e)(1-p(e))}{(p(e)\alpha+1)^2} < 0$. ■

For the case of non-envious agents, the individual bonus scheme involves zero agency costs. However, when agents are envious the principal faces positive agency costs despite the incentive effect. This result is due to the fact that the principal needs to compensate the agents for the expected disutility from inequity in order to ensure participation. We refer to this wage cost-augmenting effect as the *inequity premium effect*. This result is in line with the literature, see e.g. Bartling and von Siemens (2007) and Grund and Sliwka (2005).

2.2.2 The Repeated Game

To model the relational contract, we embed the foregoing stage game into an infinitely repeated game, considering trigger strategy equilibria. If the principal reneges on the promised bonus once, no agent will ever again believe her to fulfill the contract.[12] Hence, the principal's reputation is decisive for her ability to implement relational contracts.

As effort is not observable, agents will exert zero effort if relational contracts are infeasible, corresponding to a closure of the firm and resulting in a fallback profit of zero. If relational contracts are feasible, the principal realizes a continuation profit from the long-term relationship, corresponding to expected profit $V_b\left(e;\alpha\right)$ defined in (2.10).

For the relational contract to be self-enforcing, the gains from reneging must fall short of the gains from continuing the relational contract. This is required to hold for all realizations of performance. If both agents perform successfully, $Y_i = Y_j = 1$, the principal's incentive to renege on the relational contract is strongest, as her resulting one-time benefit from deviation amounts to twice the bonus. Concerning her reputation, it does not make any difference whether she refuses to pay just one or both bonuses. Thus, due to the separability of the profit function across workers

$$b\left(e;\alpha\right) \leq \frac{V_b\left(e;\alpha\right)}{r} \tag{CC}$$

constitutes the credibility constraint of the principal (CC).[13] The optimal relational

[12] Implicitly, we assume that the information on a principal's deviation from the relational contract is rapidly transmitted to the labor market. As Baker et al. (1994) note, each agent in the employment relationship could alternatively be represented by an infinite sequence of agents, each of whom lives for one period, provided that each period's agent learns the history of play before the period begins. See also Bull (1987) for the role of reputation in implicit contracts.

[13] We derive the rationality constraint analogously to Baker et al. (1994). Note that the interest rate r may be translated into the firm's discount rate referring to e.g. its patience. Then $r = (1-\delta)/\delta$. Hart (2001) emphasizes the discount rate's interpretation as a measure for dependency or trust between the transacting parties. Alternatively, r can be reinterpreted so that the game is not infinitely repeated but instead, in each period, the probability that the principal-agent relationship will be repeated in the following period is exogenously given by a parameter ρ. Then $r = \rho/(1-\rho)$.

contract implements e to maximize the principal's expected profit per period, subject to her credibility constraint:

$$V_b^*(r,\alpha) := \max_e V_b(e;\alpha), \quad \text{s.t. (CC)} \tag{2.12}$$

Whether condition (CC) can be satisfied or not, depends on the firm's interest rate r. To shed light on the interest rate's impact on the optimal relational contract we illustrate the credibility constraint with the help of an example in Figure 2.1. Specifically, we assume $\alpha = 0.2$, $p(e) = 1 - \exp(-e)$, $c(e) = \frac{1}{8}e^2$, and $U_0 = 0.1$. The figure plots the principal's expected per-period profit $V_b(e;\alpha)$. Moreover, the convex curves depict $rb(e;\alpha)$ for various discount rates.

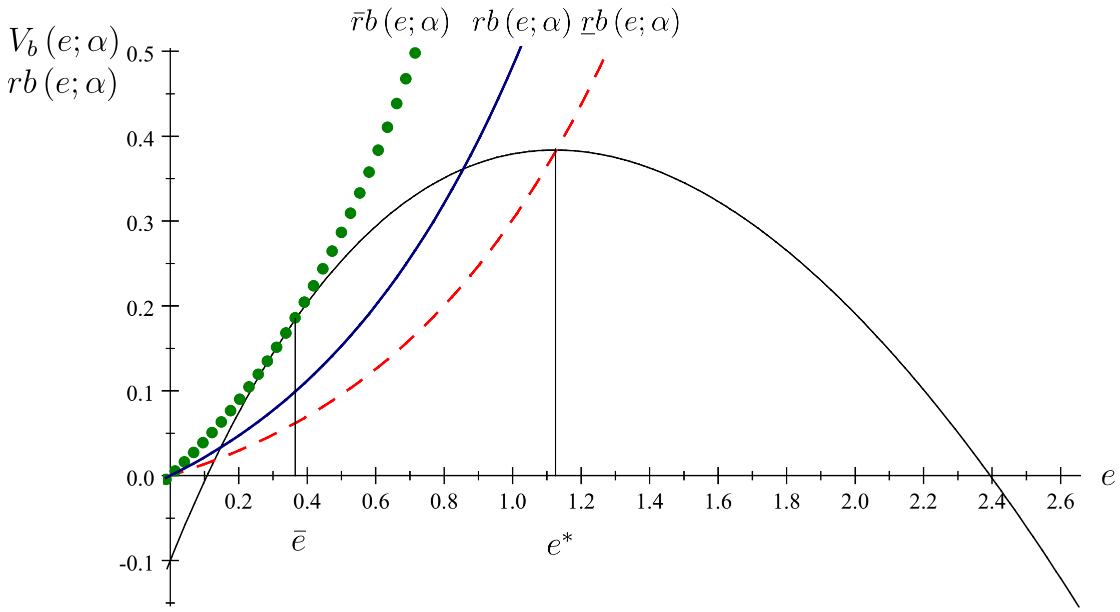

Figure 2.1: Credibility Constraint for $p(e) = 1 - \exp(-e)$, $\alpha = 0.2$, $c(e) = \frac{1}{8}e^2$, and $U_0 = 0.1$

For a sufficiently *low interest rate* the credibility constraint does not bind. The optimal relational contract implements the profit-maximizing benchmark effort level e^* (equivalent to the case of verifiable performance). We denote the threshold interest rate where (CC) becomes binding $\underline{r}$. The dashed line illustrates $\underline{r}b(e;\alpha)$.

The solid curve depicts $rb(e;\alpha)$ for a *medium interest rate* where (CC) is binding. To ensure credibility on the one hand and to maximize profits on the other hand, the principal will always choose to implement the maximum effort level that just satisfies condition (CC). Geometrically, it is given by the highest possible effort level where $V_b(e;\alpha)$ and $rb(e;\alpha)$ intersect. The figure illustrates that the optimal effort level declines as the principal's interest rate or the agents' alternative utilities increase. Intuitively, raising the interest rate implies the present value of contract continuation to decrease. Therefore the principal has to reduce the bonus in order to remain credible which implies the implementation of a lower effort level. Analogous arguments apply to an increase in the alternative utility.

As long as the credibility constraint can be fulfilled via adjustment of the implemented effort level for some given r, contracts are feasible. For a sufficiently *high interest rate* condition (CC) can no longer be satisfied. The marginal interest rate $\overline{r}$ where (CC) can just be fulfilled is characterized by $\overline{r}b(e;\alpha)$ being tangent to $V_b(e;\alpha)$. We denote the effort level implemented at this threshold $\overline{e}$. Relational contracts are infeasible for any interest rate higher than the threshold interest rate $\overline{r}$. The dotted line, $\overline{r}b(e;\alpha)$, represents this marginal case.

2.3 The Impact of Envy on the Optimal Relational Bonus Contract

In this section, we analyze the effect of the agents' propensity for envy on the profitability and feasibility of the optimal relational contract. Closer examination of condition (CC) reveals the impact of envy to be twofold. On the one hand, as shown in Proposition 2.1, we observe the *incentive effect*; $\frac{de}{d\alpha} > 0$. For a given effort level, it implies that the principal can reduce the bonus as agents become more envious.[14] Consequently, the incentive of a one-time deviation from the relational contract in order to save bonus expenses decreases. On the other hand, the *inequity premium effect* lowers the principal's profit from contract continuation; $\frac{\partial V_b(e;\alpha)}{\partial \alpha} < 0$, as shown in Proposition 2.2. Thus, fulfilling the relational contract is less attractive to the principal.

The higher the marginal interest rate $\overline{r}$, which the principal may credibly commit for, the greater is the range of interest rates where the relational contract is feasible and vice versa. Depending on the overall impact of the agents' propensity for envy on the credibility constraint, the marginal interest rate $\overline{r}$ increases or decreases.

[14]Mathematically, this follows from equation (2.6) as $\frac{\partial b(e;\alpha)}{\partial \alpha} < 0$.

Both $\overline{r}$ and $\overline{e}$ are implicitly defined as the solution of the following $2 \times 2-$ system consisting of the binding credibility constraint and the tangency condition (see Figure 2.1):

$$\begin{aligned} r &= \tfrac{V_b(e;\alpha)}{b(e;\alpha)} \\ r\tfrac{\partial b(e;\alpha)}{\partial e} &= \tfrac{\partial V_b(e;\alpha)}{\partial e} \end{aligned} \tag{2.13}$$

Conducting a comparative-statics analysis of $\overline{r}$ with respect to α, we derive the following result.

Proposition 2.3 *Suppose that performance is non-verifiable. Then an increasing propensity for envy may enhance the feasibility of the relational contract, thereby raising profits. This is the case, if and only if, at* $e = \overline{e}$*, the following condition holds:*

$$p\,(e) > \frac{(c\,(e) + U_0)\,p'\,(e) + c'\,(e)}{p'\,(e) + c'\,(e)}. \tag{2.14}$$

Proof. See the appendix 2.6. ■

The necessary and sufficient condition (2.14) assures that the incentive effect outweighs the inequity premium effect regarding the credibility constraint. The principal's incentive to renege on the bonus payments is sufficiently small such that the negative impact of envy on the continuation profit is overcompensated. Intuitively, the condition requires the continuation profit V_b to react less strongly to an increase in the degree of envy than the bonus payment b.[15] Satisfaction of the condition demands the sum of effort costs and alternative utility to be smaller than unity which is inherently fulfilled due to the model setup.[16] The smaller this sum, the more probable the feasibility-enhancing effect of envy is to arise and the stronger the effect is.[17] Further, from condition (2.14) can be inferred, that the effect is more likely to exist if the precision of the signal is large and the effort elasticity of costs is small.[18]

[15]Mathematically, by equation (2.30), this is the case if the continuation-profit elasticity is smaller in absolute terms than the bonus elasticity both with respect to the degree of envy; $-\dfrac{\partial V_b}{\partial \alpha}\dfrac{\alpha}{V_b} < -\dfrac{\partial b}{\partial \alpha}\dfrac{\alpha}{b}$.

[16]To verify this observe that the principal's expected profit (2.10) becomes negative once $p(e) < c\,(e) + \alpha p(e)\,(1 - p(e))\,b\,(e;\alpha) + U_0$. In this case, the principal would not engage in the contract. Moreover, $p(e)$ may not exceed unity. Accordingly, $c\,(e) + U_0$ can never be greater than unity.

[17]Given that the effect arises at all, in the appendix 2.6 we illustrate the impact of the alternative utility and the cost function on the effect's magnitude with the help of a numerical example. It reveals the effect to increase with decreasing U_0 and $c\,(e)$.

[18]Note that condition (2.14) can be reformulated in terms of elasticities with respect to effort: $p\,(e) > ((c\,(e) + U_0)\,\theta p\,(e) + \beta c\,(e))\,/\,(\theta p\,(e) + \beta c\,(e))$, where θ denotes the elasticity of the success probability, i.e. the precision of the signal, and β is the elasticity of costs.

Thus, we find that in the reputation game a high propensity for envy may be advantageous for the principal regarding her commitment power. Under the above condition (2.14), reputational equilibria can be sustained for a greater range of interest rates with envious agents, i.e. the credibility constraint is softened. Hence, there exist cases, where the principal can build up a long-term contractual relationship with inequity averse agents and realize profits, whereas with inequity neutral agents this is impossible.

Figure 2.2 illustrates our results for the case that condition (2.14) is satisfied and, hence, the marginal interest rate $\overline{r}$ increases in the agents' propensity for envy. The picture below shows the principal's profit under the optimal relational contract $V_b^*(r;\alpha)$ for any level of r and two different degrees of envy, $\alpha_L < \alpha_H$. The solid curve depicts her profit, if agents exhibit a certain propensity for envy, captured by α_L. The dashed curve depicts her profit for agents with a higher propensity for envy, α_H.

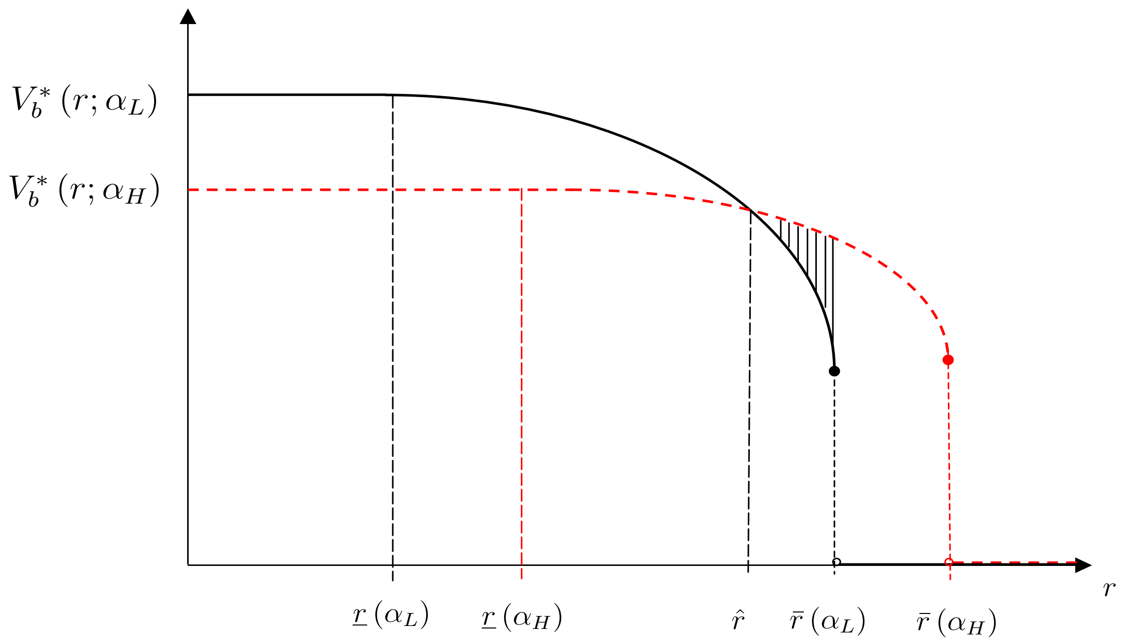

Figure 2.2: Profits for two degrees of envy, $\alpha_H > \alpha_L \geq 0$, when condition (2.14) is satisfied

For sufficiently low interest rates r, i.e. interest rates below the respective lower interest thresholds, $r \leq \underline{r}(\alpha)$, a relational contract is feasible and the optimal effort level e^* is implemented by the principal. $V_b^*(e^*;\alpha)$ is realized. Proposition 2.2 implies that, for any $r < \underline{r}(\alpha_L)$, profits with less envious agents exceed those with more envious agents; $V_b^*(r, \alpha_H) < V_b^*(r, \alpha_L)$.

For any interest rate r in-between the respective lower and upper threshold levels, i.e. $\underline{r}(\alpha) < r \leq \overline{r}(\alpha)$, effort e is adapted such that (CC) is fulfilled. Profits in the optimum, $V_b^*(e; \alpha)$, decrease in this range as interest rates increase. However, depending on the value of α, profits decrease at different rates. Observe that in Figure 2.2, when r takes a value higher than the critical value $\widehat{r}$, continuation profits from employing envious agents exceed those from employing less envious ones (shaded area); $V_b^*(r, \alpha_H) > V_b^*(r, \alpha_L) > 0$.

In addition, by Proposition 2.3, for any r in-between the two upper thresholds, i.e. $\overline{r}(\alpha_L) < r \leq \overline{r}(\alpha_H)$, relational contracts are yet feasible with more envious agents, whereas the principal cannot credibly commit herself when dealing with less envious ones. Thus positive profits are realized only with the former; $V_b^*(r, \alpha_H) > V_b^*(r, \alpha_L) = 0$.[19]

The following corollary summarizes the above illustrated insights with respect to the beneficial effects of envy regarding the profitability of relational contracts.

Corollary 2.1 *Suppose that performance is non-verifiable and condition (2.14) is satisfied. Let* $0 \leq \alpha_L < \alpha_H$.
(i) Given that the difference in the agents' degree of envy, $\alpha_H - \alpha_L$, *is sufficiently small, there exists a critical value* $\widehat{r} < \overline{r}(\alpha_L)$ *where the two profit curves* $V_b^*(r; \alpha_L)$ *and* $V_b^*(r; \alpha_H)$ *intersect. In this case the principal prefers to employ the more envious agents for any interest rate* $\widehat{r} < r \leq \overline{r}(\alpha_H)$, *as profits with more envious agents exceed those with less envious ones (see Figure 2.2).*
(ii) Given that the difference in the degrees of envy, $\alpha_H - \alpha_L$, *is sufficiently large, the two profit curves* $V_b^*(r; \alpha_L)$ *and* $V_b^*(r; \alpha_H)$ *do not intersect. In this case the principal prefers to employ more envious agents over less envious ones for any interest rate* $\overline{r}(\alpha_L) < r \leq \overline{r}(\alpha_H)$, *as positive profits are realized only with the former.*

To put it differently, the principal definitely prefers to employ more envious over less envious agents, whenever commitment is feasible only with more envious ones.

[19] For any α, the values of the lower and the upper threshold interest rates depend on the specifically assumed functional forms and the value of the alternative utility. For a numerical example, see the appendix 2.6.

Given that agents are not too different with respect to their propensities for envy, the same holds true for an extended range of interest rates where, albeit contracts with both types of agents feasible, profits with more envious agents exceed those with less envious ones.

2.4 Discussion and Extensions

In the preceding sections we have analyzed peer-independent performance pay and focused on the trade-off between credibility and the costs of inequity aversion. In doing so we have ignored contracts based upon peer-dependent performance evaluation like rank-order tournaments and group bonus contracts. However, these alternative compensation schemes have interesting features in our setup. In particular, the former avoids credibility problems altogether. Yet, as we will show, this comes at the cost of a larger inequity premium. At the other extreme, a group bonus contract excludes the possibility of unequal pay. We find, however, that it amplifies the credibility problem. In the following, we briefly outline the two alternative types of compensation contracts for the case of envious agents and discuss the implications for our results. In particular, in sections 2.4.1 and 2.4.2, we verify that the restriction to individual bonus contracts is meaningful for a range of sufficiently high interest rates. Moreover, in section 2.4.3, we demonstrate that employing more envious agents may still be preferred by the principal, even if she has the choice between contracts based on individual, group, or relative performance.

2.4.1 Group Bonus Scheme

In a group scheme, the principal offers each agent a compensation contract $\left\{w_B, B_{Y_iY_j}\right\}$, where w_B is a guaranteed fixed wage and $B_{Y_iY_j}$ a (per-worker) group bonus which is paid contingent upon both agents' performances Y_i and Y_j in the respective period. Whenever paid out, the group bonus is paid to both agents such that inequity in payoffs never occurs. Depending on the signals' realizations, the group incentive scheme allows for the implementation of three different bonus payments, B_{01}, B_{10}, and B_{11}. A thorough analysis of the group scheme under non-verifiable performance is conducted by Kragl (2008).[20] In the following, we summarize some of her results which are relevant for the current analysis and their intuition.

[20]This paper is presented in chapter 3 of the present thesis.

In the repeated game, the optimal group scheme implements the smallest possible bonus payment for a given level of effort in order to facilitate credibility. Depending on the value of $p(e)$, either of two group bonus schemes is optimal.[21] With $p(e) \leq 0.5$, the group bonus is paid whenever at least one agent is successful. In contrast, with $p(e) > 0.5$, the group bonus is paid only if both agents are simultaneously successful. All results concerning the comparison of the group to the individual bonus scheme equivalently hold for either case. In the following, we only outline the case $p(e) \leq 0.5$ and discuss the arising trade-off.

Assume that the principal promises to pay a bonus B to both agents whenever at least one agent is successful. In the single-period game, agent i's expected utility is

$$E[U_i|e_i, e_j] = w_B + (p(e_i) + p(e_j) - p(e_i)\, p(e_j))\, B - c(e_i), \quad i \neq j, \tag{2.15}$$

where e_i and e_j denote the respective effort levels of worker i and his co-worker j. Observe that the agents' inequity-averse preference structure has no effect on their respective utilities in the presence of the group scheme. In the unique symmetric Nash-equilibrium of the one shot game, the first-order condition of (2.15) yields the incentive-compatible bonus for implementing a given effort level e:

$$B(e) = \frac{c'(e)}{(1 - p(e))\, p'(e)} \tag{2.16}$$

Comparing equations (2.6) and (2.16) reveals that the size of the incentive-compatible group bonus $B(e)$ exceeds the size of the individual bonus $b(e;\alpha)$ for any given effort level e and any level of $\alpha \geq 0$. Intuitively, the group bonus introduces a positive externality effect of an agent's effort on the other agent's expected payoff. As a result, the probability of obtaining the bonus is less responsive to changes in effort in the group scheme than in the individual scheme, and, hence, the group bonus must be larger to elicit an equivalent effort level. Moreover, in contrast to the individual scheme, in the group scheme there is no incentive-strengthening effect of envy.

In the repeated game, the principal sets B, w_B, and e to maximize expected profits per agent and period subject to incentive compatibility, participation, and credibility constraints. Given that the participation constraint is binding, we can eliminate w_B

[21] For a comprehensive analysis and the derivation of this result see chapter 3.

such that the principal's problem becomes:

$$\begin{array}{lll} V_B^*(r) := & \max\limits_{e,B} & V_B(e) = p(e) - c(e) - U_0 \\ \text{s.t.} & & \\ (\text{IC}_B) & & (1-p(e))\, p'(e)\, B = c'(e) \\ (\text{CC}_B) & & B \leq \frac{V_B(e)}{r} \end{array} \tag{2.17}$$

From the optimization program can be inferred that, in the group scheme, as long as the interest rate is such that the credibility constraint is not binding, first-best effort levels e^{FB} can be implemented, regardless of the agents' propensity for envy. Observe that, by equation (2.10), this is also true for profits in the individual scheme for the case of non-envious agents, i.e. $V_B^*(r) = V_b^*(r;0)$. However, as the interest rate increases, in both types of contract the respective credibility constraints become binding at some interest rate. Since the group bonus is larger, $B\left(e^{FB}\right) > b\left(e^{FB};0\right)$, (CC_B) necessarily becomes binding for a lower value of r than (CC). In other words, $V_B^*(r)$ starts declining for a smaller value of r than $V_b^*(r;0)$.

Altogether, for any interest rate, the principal is never worse off using an individual bonus contract with non-envious agents as compared to using a group bonus contract, i.e. $V_b^*(r;0) \geq V_B^*(r)$. Moreover, in section 2.3 we have shown that for sufficiently large interest rates the principal prefers envious agents to non-envious agents using an individual bonus scheme for a range of interest rates.[22] Thus, a fortiori, for this range of interest rates, she also prefers the individual scheme to the group bonus scheme when agents are envious. We illustrate this result in Figure 2.3(a). Observe that the principal indeed prefers the individual bonus scheme for any interest rate $r > \tilde{r}$, given that agents are envious.

2.4.2 Rank-order Tournament

In a rank-order tournament, the principal does not face any credibility problem since she can ex ante commit to paying out a given sum of wages in each period.[23] In the current context, suppose she offers a fixed wage w_Δ to each agent and distributes a prize Δ among the agents in each period. In particular, she pays Δ to the winner if one

[22] This holds when condition (2.14) is satisfied. See Proposition 2.3.

[23] In this sense, a tournament is no relational contract as it solves the non-verifiability problem. In contrast to bonus contracts, however, tournaments suffer from collusion and sabotage (see e.g. Lazear (1989)).

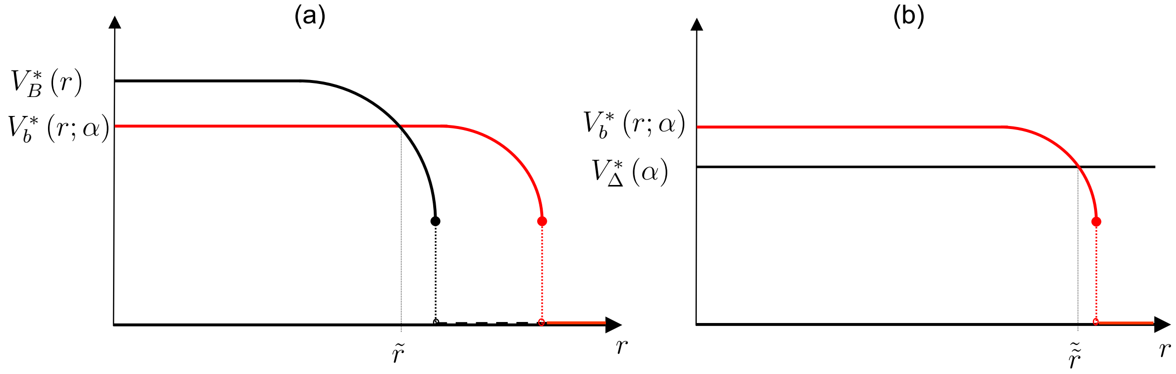

Figure 2.3: Profits in (a) the individual and the group scheme and (b) the individual scheme and the tournament, for a given degree of envy, $\alpha > 0$, and provided that condition (2.14) is satisfied

exists. When contributions are equal, she pays $\frac{\Delta}{2}$ to each agent.[24] In the single-period game, when exerting effort e_i while his co-worker exerts effort e_j agent i's expected utility is

$$\begin{aligned} E[U_i|e_i,e_j] = w_\Delta + (1 + p(e_i) - p(e_j))\frac{\Delta}{2} - c(e_i) \\ -\alpha p(e_j)(1-p(e_i))\Delta, \quad i \neq j. \end{aligned} \tag{2.18}$$

In the symmetric Nash-equilibrium of the one shot game, the first-order condition of (2.18) yields the incentive-compatible tournament prize for implementing effort e:

$$\Delta(e;\alpha) = \frac{c'(e)}{\left(\frac{1}{2} + \alpha p(e)\right) p'(e)} \tag{2.19}$$

Comparing equations (2.19) and (2.6) we find that the principal has to offer a tournament prize larger than the individual bonus for any e and any $\alpha \geq 0$, $\Delta(e;\alpha) > b(e;\alpha)$. Intuitively, by paying out $\frac{\Delta}{2}$ when agents are both either successful or not, the principal avoids the credibility problem but weakens the incentives. Thus, to induce the same effort level, the principal is forced to raise Δ above b. Given that agents are envious, this is not innocuous. Specifically, it lowers the principal's profit as shown below.

The principal sets Δ, w_Δ, and e to maximize expected profits per agent and period subject to incentive compatibility, participation, and credibility constraints. Given

[24]Observe that in the current context, randomizing and paying Δ to only one of the agents would necessarily worsen the outcome due to the inequity aversion of the parties. It is worth pointing out that, in contrast to the standard literature on tournaments (see e.g. Lazear and Rosen, 1981), in our set-up the probability of equal signal realizations is positive as signals are binary.

that the participation constraint is binding, we can eliminate w_Δ, and the principal's problem becomes

$$V_\Delta^*(\alpha) := \max_{e,\Delta} V_\Delta(e;\alpha) = p(e) - c(e) - \alpha p(e)(1-p(e))\Delta - U_0, \quad \text{s.t. } (2.19). \tag{2.20}$$

Observe that, by equations (2.10) and (2.20), tournament profits $V_\Delta^*(\alpha)$ are lower than profits in the individual incentive scheme $V_b^*(r;\alpha)$ for any value $\alpha > 0$ and sufficiently small interest rates.[25] This is due to the fact that, with envious agents, the relative payment structure induces even higher inequity costs than the individual bonus contract.[26] Note, however, that in contrast to profits from the individual scheme, tournament profits are unaffected by an increase in the interest rate. Thus, for sufficiently high interest rates, the tournament outperforms the individual incentive scheme as the credibility problem becomes paramount in the latter. Figure 2.3(b) illustrates this result. For any interest rate $r < \tilde{\tilde{r}}$, the principal prefers the individual bonus contract to the tournamtent, when agents are envious. This is true irrespective of whether condition (2.14) is fulfilled. Yet, if condition (2.14) holds, the individual bonus contract is superior to the tournament for a greater range of interest rates.

2.4.3 Effects of an Increasing Propensity for Envy

In the foregoing section we found that, with envious agents, the individual bonus structure remains preferable for a meaningful range of interest rates. In the remainder, we show that the intuition of Proposition 2.3 and Corollary 2.1 carries over to the comparative analysis of all three incentive schemes. Specifically, we demonstrate, that employing more envious agents may still be preferred by the principal, even if she can select one of the three considered incentive contracts. Figure 2.4 illustrates the effects of a small increase in envy. It sketches optimal profits under the different incentive schemes for two different degrees of envy, $\alpha_L < \alpha_H$, and . The solid curves depict profits for α_L, the dashed curves those for α_H, respectively.

Note that profits in the group scheme are not affected by an increase in α. In contrast, tournament profits decrease when α increases from α_L to α_H for any interest rate. By Proposition 2.2 and Corollary 2.1, for the considered increase in α, profits

[25] Note that, for non-envious agents, the tournament implements first-best effort levels. However, once agents exhibit some propensity for envy, the individual contract is superior for a considerable range of interest rates.

[26] See Grund and Sliwka (2005) for a comprehensive analysis of the inequity costs in tournaments.

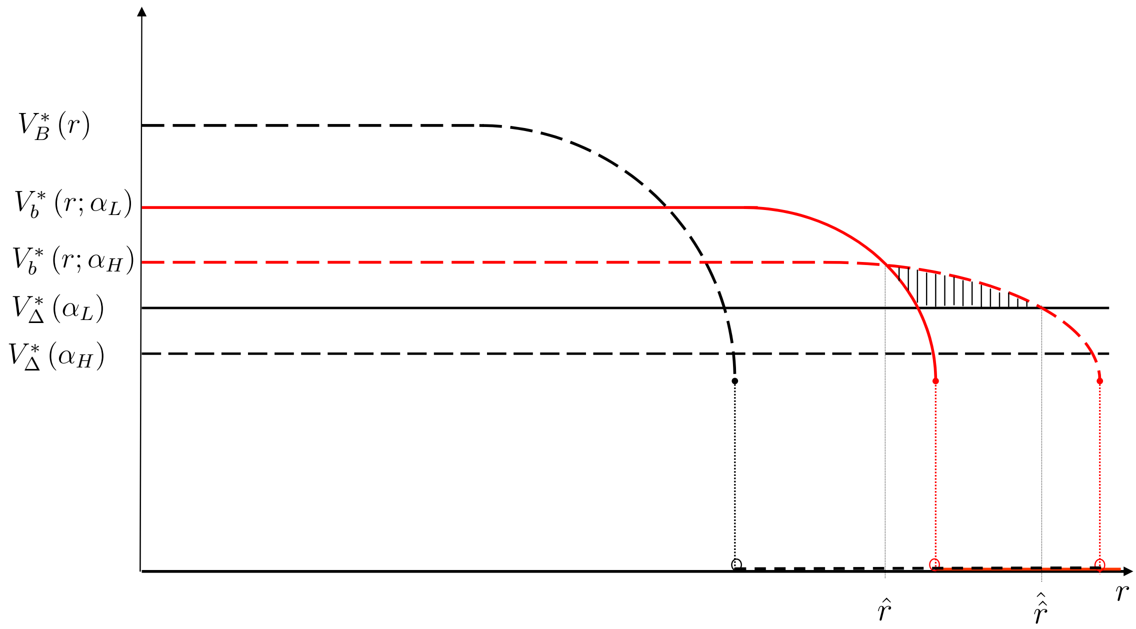

Figure 2.4: Profits in the individual, the group scheme, and the tournament for two different degrees of envy, where $\alpha_H > \alpha_L > 0$, given that condition (2.14) is satisfied

in the individual incentive scheme decrease for interest rates $r < \widehat{r}$ and increase for interest rates $r > \widehat{r}$ as long as a contract is feasible and given that condition (2.14) holds. The figure reveals that for any interest rate $r \in \left(\widehat{r}, \widehat{\widehat{r}}\right)$, the principal indeed prefers to use the individual bonus scheme and to employ more envious agents rather than to implement a tournament with less envious agents, and certainly rather than to implement a group scheme. The shaded area depicts the supplemental profit the principal may realize by employing more envious agents under an individual bonus contract.

2.5 Concluding Remarks

We consider optimal individual incentive schemes in a principal-agent relationship with two identical agents who exhibit horizontal disadvantageous inequity aversion. As there are only subjective performance measures available to evaluate the agents' performances, the bonus contracts are enforced in a reputational equilibrium.

The analysis focuses on the impact of the agents' propensity for envy on the principal's commitment power that determines the feasibility of the relational contract.

There are two countervailing effects at work: On the one hand, as agency costs increase due to the presence of envy, the principal's profits from the contract decrease as agents become more envious. Thus, continuation of the relational contract becomes less attractive. On the other hand, envy serves as an incentive-strengthening device. This implies that the principal has to pay a lower bonus to implement the same effort given that agents are envious, thereby reducing her benefit from a one-time deviation. We identify a necessary and sufficient condition assuring that the principal's ability to commit increases as agents become more envious. This implies that the principal prefers to employ more envious agents over less envious ones for a range of high interest rates.

In our paper, we abstract from empathy, captured via the parameter $\beta > 0$ in the model by Fehr and Schmidt (1999). Some studies claim that people might actually be better off if their payoff exceeds the payoffs of others in their peer group, implying that these people are spiteful and/or show preferences for status.[27] This is contrary to empathy and could be captured by $\beta < 0$. Assuming this kind of preferences in addition to envy would strengthen our results as status seeking and spitefulness respectively lead to stronger incentives on the one hand and act contrary to the expected disutility from envy on the other hand.[28] Thus, the higher status concerns or spiteful behavior, the more probable the positive effect of envy on relational contracts is achieved.

To complete the analysis, we outline two alternative types of contracts, both based upon peer-dependent performance pay. First, we briefly consider a group bonus contract which inherently avoids unequal outcomes and thus implies an inequity premium of zero, but amplifies the credibility problem. Second, we look at a rank-order tournament where the principal does not face a credibility problem, but increased inequity costs instead. We show that there exists a beneficial effect of envy which carries over to the comparative analysis of all three incentive schemes.

[27] See e.g. Loewenstein et al. (1989), Brown, Gardner, Oswald, and Qian (2005), and Moldovanu, Sela, and Shi (2007).

[28] See Grund and Sliwka (2005) for spitefulness in the context of tournaments.

2.6 Appendix

Proofs for section 2.2

Proof of symmetry and uniqueness of the Nash-equilibrium in the single-period game under individual performance pay. Both agents maximize their expected utility (2.4). The respective first-order conditions are given by

$$p'(e_i)\,b - c'(e_i) + \alpha p'(e_i)\,p(e_j)\,b = 0, \tag{2.21}$$
$$p'(e_j)\,b - c'(e_j) + \alpha p'(e_j)\,p(e_i)\,b = 0. \tag{2.22}$$

Combining both equations implies

$$\frac{c'(e_i)}{p'(e_i)\,(1+\alpha p(e_j))} = \frac{c'(e_j)}{p'(e_j)\,(1+\alpha p(e_i))} \tag{2.23}$$

$$\Leftrightarrow \frac{c'(e_i)\,(1+\alpha p(e_i))}{p'(e_i)} = \frac{c'(e_j)\,(1+\alpha p(e_j))}{p'(e_j)}. \tag{2.24}$$

Both sides of equation (2.24) represent a function of the agent's effort level:

$$\frac{c'(e)\,(1+\alpha p(e))}{p'(e)} \tag{2.25}$$

Since (2.25) is monotonically increasing in e, equation (2.24) is satisfied if and only if $e_i = e_j = e$. To see this, consider the derivative of (2.25) with respect to effort:

$$\frac{(1+\alpha p(e))p'(e)\,c''(e) + \alpha p'(e)^2\,c'(e) - p''(e)\,c'(e)\,(1+\alpha p(e))}{p'(e)^2}. \tag{2.26}$$

As $\alpha, p(e), p'(e), c''(e), c'(e) > 0$, and $p'' < 0$, (2.26) is strictly positive. Moreover, as e maximizes the agents' concave utility function (2.4), the equilibrium is also unique. ∎

Proofs for section 2.3

Proof of Proposition 2.3. Differentiation of $\overline{r}$ yields

$$\frac{\partial \overline{r}}{\partial \alpha} = \frac{\left(\left.\frac{\partial V_b}{\partial e}\right|_{e=\overline{e}} b - V_b \left.\frac{\partial b}{\partial e}\right|_{e=\overline{e}}\right)\frac{\partial e}{\partial \alpha} + \left.\frac{\partial V_b}{\partial \alpha}\right|_{e=\overline{e}} b - V_b \left.\frac{\partial b}{\partial \alpha}\right|_{e=\overline{e}}}{b^2}. \tag{2.27}$$

The system (2.13) implies

$$\left.\frac{\partial V_b}{\partial e}\right|_{e=\overline{e}} b\left(\overline{e};\alpha\right) - V_b(\overline{e};\alpha)\left.\frac{\partial b}{\partial e}\right|_{e=\overline{e}} = 0. \tag{2.28}$$

With equation (2.28), (2.27) simplifies to

$$\frac{\partial \overline{r}}{\partial \alpha} = \frac{\left.\frac{\partial V_b}{\partial \alpha}\right|_{e=\overline{e}} b - V_b \left.\frac{\partial b}{\partial \alpha}\right|_{e=\overline{e}}}{b^2}. \tag{2.29}$$

To decide upon the effect of α on $\overline{r}$ the sign of equation (2.29) is crucial:

$$sign\left(\frac{\partial \overline{r}}{\partial \alpha}\right) = sign\left(\left.\frac{\partial V_b}{\partial \alpha}\right|_{e=\overline{e}} b - V_b \left.\frac{\partial b}{\partial \alpha}\right|_{e=\overline{e}}\right) \tag{2.30}$$

Substituting V_b as given in equation (2.10) and with

$$\frac{\partial V_b\left(\overline{e};\alpha\right)}{\partial \alpha} = -b\left(1-p\left(\overline{e}\right)\right)p\left(\overline{e}\right) - \alpha\left(1-p\left(\overline{e}\right)\right)p\left(\overline{e}\right)\left.\frac{\partial b}{\partial \alpha}\right|_{e=\overline{e}}$$

equation (2.30) further simplifies to

$$sign\left(\frac{\partial \overline{r}}{\partial \alpha}\right) = sign\left(-b^2\left(1-p\left(\overline{e}\right)\right)p\left(\overline{e}\right) - \left(p\left(\overline{e}\right) - c\left(\overline{e}\right) - U_0\right)\frac{\partial b}{\partial \alpha}\right). \tag{2.31}$$

With $b\left(\overline{e};\alpha\right) = \frac{c'(\overline{e})}{(1+\alpha p(\overline{e}))p'(\overline{e})}$ as given in (2.6) and

$$\frac{\partial b\left(\overline{e};\alpha\right)}{\partial \alpha} = -\frac{c'\left(\overline{e}\right)p\left(\overline{e}\right)p'\left(\overline{e}\right)}{\left(\left(1+\alpha p\left(\overline{e}\right)\right)p'\left(\overline{e}\right)\right)^2}$$

equation (2.31) results in

$$sign\left(\frac{\partial \overline{r}}{\partial \alpha}\right) = sign\left(-c'\left(\overline{e}\right)\left(1-p\left(\overline{e}\right)\right) + \left(p\left(\overline{e}\right) - c\left(\overline{e}\right) - U_0\right)p'\left(\overline{e}\right)\right). \tag{2.32}$$

Thus,

$$\tfrac{\partial \overline{r}}{\partial \alpha} > 0 \quad \text{iff} \quad p\left(\overline{e}\right) > \tfrac{(c(\overline{e})+U_0)p'(\overline{e})+c'(\overline{e})}{p'(\overline{e})+c'(\overline{e})}.$$

■

Numerical Example of the Effect of Envy on the Interest Thresholds and Graphical Illustration.

For the numerical example, we assume $p(e) = 1 - \exp(-e)$ and $c(e) = Ke^2$. The table below lists numerical results for the interest thresholds from our model for two different degrees of envy ($\alpha = 0$ and $\alpha = 1$) and two different values of U_0 and K, respectively. Given that condition (2.14) is satisfied, the table illustrates the effect of envy of on the principal's commitment power as it shows the increase in the respective interest threshold levels that results from an increase in α.

		Lower interest threshold		Upper interest threshold	
U_0	K	$\underline{r}\,(0)$	$\underline{r}\,(1)$	$\overline{r}\,(0)$	$\overline{r}\,(1)$
0.36	0.075	0.25	0.39	0.53	0.59
0.39	0.075	0.22	0.32	0.43	0.45
0.39	0.05	0.28	0.51	0.74	0.93

The examples reveal a converse impact of both parameters, U_0 and K, on the magnitude of the effect of envy; with decreasing values of each, the spans $\overline{r}\,(1) - \overline{r}\,(0)$ as well as $\underline{r}\,(1) - \underline{r}\,(0)$ increase. Consider for example the upper interest threshold. When U_0 falls from 0.39 to 0.36 and K remains constant, the difference in the interest levels increases from 2% to 6%. A decrease in K from 0.075 to 0.05, with U_0 constant, causes an increase in the difference of the upper thresholds by 17%.

Additionally, the plots below graphically illustrate the effect of the parameters U_0 and K on our results for the functional forms given above and for a range of different parameter values. The left picture presents their impact on the magnitude of the feasibility-enhancing effect of envy for a change of α from 0 to 1 as it plots the difference of the respective upper interest thresholds. The right picture shows the impact on the upper threshold level for $\alpha = 0.2$.

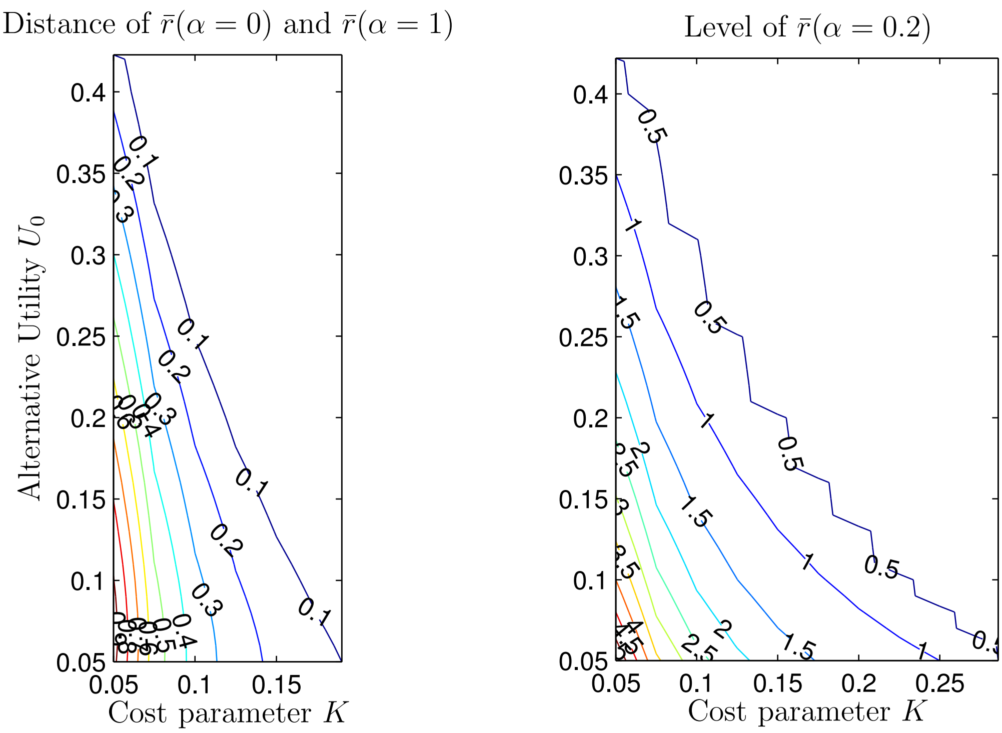

Figure 2.5: Effects of U_0 and K on the magnitude of the feasibility-enhancing effect of envy (left) and the level of the upper interest threshold (right)

Chapter 3

Group vs. Individual Performance Pay in Relational Employment Contracts when Workers Are Envious

I compare group to individual performance pay when workers are envious and performance is non-verifiable. Avoiding payoff inequity, the group bonus contract is superior as long as the firm faces no credibility problem. The individual bonus contract may, however, become superior albeit introducing the prospect of unequal pay. This is due to two reasons: The group bonus scheme is subject to a free-rider problem requiring a higher incentive pay and impeding credibility of the firm. Moreover, with individual bonuses the firm benefits from the incentive-strengthening effect of envy, allowing for yet smaller incentive pay and further softening the credibility constraint.

3.1 Introduction

The present paper investigates how agents' concerns for fairness affect the optimal provision of incentives in a moral-hazard framework with non verifiable performance measures. The existing literature on incentive schemes under inequity aversion has mainly analyzed explicit contracting. In these environments, employing inequity averse agents comes at a cost for the principal.[1] An exception is the study by Kragl and

[1]Compared to the first-best efficient benchmark with purely self-interested, not wealth-constrained agents, inequity aversion entails agency costs. See e.g. Neilson and Stowe (2008), Bartling and von Siemens (2007), and Grund and Sliwka (2005).

Schmid (2008) which examines an infinitely repeated game where observed performance is non-verifiable.[2] Their analysis focuses on individual performance compensation; it shows that in contrast to the situation with objective performance measures, employing inequity averse agents may become advantageous to the principal. In the present paper, I introduce in a similar framework the possibility of group compensation and compare its advantage with the individual bonus scheme.

Most employment relationships suffer from moral hazard because an employee's effort is not observable by the firm. Nevertheless, in many cases the employee's performance can be observed by the contracting parties.[3] Though an incentive contract is then not court-enforceable, the observed performance may be used in an agreement that must, however, be self-enforcing. Such agreements are called relational contracts and may be sustained in long-term relationships as reputational equilibria.[4] As employment contracts are usually long-term and employer and workers thus interact repeatedly, relational contracts exhibit realisitic features of real-word incentive schemes.

Moreover, individual employment relationships are typically embedded in the larger framework of the firm, thus in a social context where individual comparison may play a role. Experimental evidence suggests that workers not only care about absolute but also about relative payoffs.[5] Hence, the employer must take into account that her decisions regarding one worker might affect other employment relationships within the same organization. When workers are inequity averse, i.e. when they resent being paid more or less than their co-workers, the prospect of unequal pay implies additional agency costs for the firm, the so-called inequity premium. These costs arise whenever the workers face a positive probability of receiving unequal wages as is the case with imperfect performance measures and individual performance pay.[6]

[2]This paper is presented in chapter 2 of the present thesis.

[3]Third parties, as e.g. a court, are often not able to verify each piece of information that is available to the principal. Moreover, it will often be too costly or even impossible to credibly communicate the agent's contribution to firm value to an outside party. See e.g. Milgrom and Roberts (1992) and Holmström and Milgrom (1994).

[4]Reputational equilibria may exist if one party cares about her reputation in future relationships. In particular, the parties may prefer to stick to the implicit agreement if there is a credible future punishment threat in case they renege on the agreement. See e.g. Holmström (1981), Bull (1987), Baker et al. (1994), or Baker et al. (2002).

[5]See e.g. Goranson and Berkowitz (1966), Berg et al. (1995), and Fehr et al. (1998). For an overview of the experimental literature on other-regarding preferences see Camerer (2003) or Fehr and Schmidt (2006).

[6]This might not be true when workers earn rents (see Demougin and Fluet, 2003, 2006; Bartling and von Siemens, 2007). Inequity aversion strenghthens incentives and can thus be beneficial when workers are financially constrained. Assuming no financial constraint on either side, however, workers earn no rents in my setup.

In the existing literature, it is frequently argued that concerns for equity or fairness could serve as an explanation for observed wage compressions or the absence of individual performance pay.[7] The implementation of joint-performance evaluation such as a group compensation scheme rules out the possibility of unequal payoffs across workers. Thus, when a firm employs more than one worker, even if there are no complementarities in production, it may choose to pay a group bonus, solely for the purpose of avoiding agency costs resulting from inequity aversion. While the present paper in a first step verifies the above intuition for contractible performance, its main purpose is to investigate whether a group bonus contract is still preferrable when performance is non-verifiable. In particular, assuming inequity averse preferences on the workers' sides, I investigate the feasibility and profitability of relational group bonus contracts compared to the case of relational individual bonus contracts as investigated by Kragl and Schmid (2008). It turns out that, in contrast to the situation with verifiable performance, individual bonus contracts possibly perform better.

Formally, I analyze an infinitely repeated game with one long-lived firm and a sequence of two short-lived workers. Workers are risk neutral, not financially constrained and consigned to work on a similar task which is valuable for the firm.[8] Following Fehr and Schmidt (1999), I assume them to exhibit 'self-centered inequity aversion'. The parties observe each worker's individual output which is an imperfect and non-verifiable signal of the worker's effort. To mitigate the moral hazard problem, the firm can offer the workers a bonus contract contingent upon either individual output or an aggregated measure of both workers' outputs. In order to guarantee self-enforcement of the respective incentive contracts, reputation concerns have to restrain the firm from deviating. Specifically, credibility requires the firm's gains from reneging on the bonus to fall short of the discounted gains from continuing the relational contract.[9]

When workers are not envious, both the group bonus and the individual bonus contract implement first-best effort levels as long as the firm's discount rate is sufficiently large. Given that workers are envious, however, the group bonus contract dominates the individual bonus contract. This is due the fact that, by adopting an individual

[7]See e.g. Baker et al. (1988). In a survey study, Bewley (1999) finds that internal pay structures aim at providing internal pay equity. In recent theoretical studies, Englmaier and Wambach (2005), Goel and Thakor (2006) and Bartling (2008) show that inequity averse preferences among agents may render team incentives optimal.

[8]Typically, workers in such a situation tend to compare their payoffs with those of their colleagues. For the importance of reference groups, see e.g. Loewenstein et al. (1989).

[9]I model the repeated-game structure and the self-enforcement constraint following Baker et al. (1994) who analyze relational incentive contracts with non-inequity averse agents.

bonus structure, the firm incurs additional expenses for inequity premiums.

Once the firm's discount rate is sufficiently small, however, the group bonus that implements first-best efforts induces the firm to renege on its promise. Credibility then requires reducing the group bonus thereby inducing non-optimal effort levels which lead to smaller profits. In comparison, the individual bonus provides two benefits. First, a group bonus introduces a free-rider problem. Hence, it must be larger than the respective individual bonus for implementing a given level of effort. Second, using a group bonus, the firm cannot exploit the incentive-strenghtening effect of inequity which allows for lowering the bonus level under individual performance pay.[10] Both of these features facilitate credible commitment in the individual bonus contract.

Accordingly, there are combinations of inequity aversion and discount rates for which the relational individual bonus contract is more profitable than the group bonus contract. Moreover, there are cases where the group contract becomes yet infeasible whereas the individual bonus contract still yields positive profits.

The present paper brings together important aspects of the literature on relational contracts and that on inequity aversion. In the last decade, economists have increasingly recognized the relevance of other-regarding preferences. Alternative approaches regarding their formalization have been proposed, e.g. by Rabin (1993), Fehr and Schmidt (1999), Bolton and Ockenfels (2000), and Falk and Fischbacher (2006). By now there is a growing literature linking standard incentive theory and social preferences. Much of the work is associated with the impact of inequity aversion on individual incentive contracts under verifiable performance. Moreover, the majority of papers focuses on mutually inequity averse agents (e.g. Bartling and von Siemens, 2007; Neilson and Stowe, 2008; Demougin et al., 2006).[11] The effects of such preferences on tournaments are analyzed by Grund and Sliwka (2005) and Demougin and Fluet (2003). Other papers compare the efficiency of different incentive regimes when workers are concerned with relative payoffs (e.g. Bartling and von Siemens, 2007; Rey-Biel, 2008; Demougin and Fluet, 2006; Goel and Thakor, 2006; Itoh, 2004). I complement this literature by extending the analysis of incentive provision with mutually inequity averse agents to non-verifiable performance measures which requires a dynamic relational-contract setting.

[10]See also Bartling and von Siemens (2007), Grund and Sliwka (2005), Demougin and Fluet (2006), and Kragl and Schmid (2008) for the motivating effect of inequity aversion.

[11]Englmaier and Wambach (2005) and Dur and Glazer (2008) examine incentive contracts when agents care about inequality relative to the principal.

Earlier contributions on relational contracts have focused on environments with symmetric information (e.g. Bull, 1987; MacLeod and Malcomson, 1989; Levin, 2002). More recent papers analyze self-enforcing contracts under asymmetric information, in particular moral hazard in effort (e.g. Baker et al., 1994, 2002; Levin, 2003; Schöttner, 2008). Moreover, some papers compare the efficiency of different incentive regimes for multiple agents in a dynamic setting. Che and Yoo (2001) study the interaction of explicit and implicit incentives in teams while focusing on employee cooperation as self-enforcing behaviour. Kvaløy and Olsen (2006) extend the latter analysis by assuming that the agents' output is non-verifiable either. Kvaløy and Olsen (2007) provide an explanation for the prevalence of individual performance pay in a related setting where agents possess indispensable human capital. I contribute to that strand of literature by introducing fairness concerns among agents into the analysis of two different incentive regimes under non-verifiable performance; the study offers a complementary, preference-dependent explanation as to why either individual or team incentives may be optimal in repeated employment relationships.

Most closely related to the present paper is Kragl and Schmid (2008). In that paper, we show that, with individual performance pay, inequity aversion may enhance the profitability and feasibility of relational contracts. The present analysis complements the former by introducing the possibility of group bonus contracts. My findings underline that empirically observed cultural differences in social preferences should not be neglected in organizational decisions when firms rely on implicit incentives (self-enforcing agreements). In particular, the impact of other-regarding preferences on the design of incentive schemes shows to be sensitive to the verifiability of the underlying performance measures and, thus, also to the time horizon of employment.

The paper proceeds as follows. The next section describes the basic economic framework. Section 3.3 addresses the agency problem in the single-period game. Section 3.4 analyzes the reputation game. I first derive the firm's credibility constraints under the two incentive regimes and determine the optimal relational group contract. Then I deduce conditions for the superiority of either the group or the individual compensation scheme by investigating the impact of inequity aversion on the equilibrium contracts. Section 3.5 discusses the implications and offers some concluding remarks.

3.2 The Model

I consider a repeated game between an infinitely long-lived firm, hereafter the principal, and an infinite sequence of two homogeneous short-lived workers, hereafter the agents.[12] All parties are risk neutral and not financially constrained. In each period, agent i ($i = 1, 2$) chooses an unobservable effort level e_i that causes him private cost $c(e_i)$ with $c(0) = 0$, $c'(0) = 0$, $c'(e_i) > 0$ for $e_i > 0$, and $c''(e_i) \geq 0$. This effort choice stochastically determines his contribution to firm value Y_i which may be either high or low; $Y_i \in \{0, 1\}$. Albeit non-verifiable, the agent's contribution Y_i is observable by all contracting parties. By exerting effort, agent i positively affects the probability of a high contribution:

$$\Pr[Y_i = 1|e_i] = p(e_i), \tag{3.1}$$

where $p(e_i) \in [0, 1)$, $p(0) = 0$, $p'(e_i) > 0$, and $p''(e_i) < 0$. The realizations of the agents' respective contributions to firm value are stochastically independent events. Moreover, there are no complementarities in production such that the principal's profit function is separable across agents. Altogether, the principal's one-period profit per agent is that worker's contribution to firm value net of wage costs π_i:

$$V(Y_i, \pi_i) = Y_i - \pi_i, \quad i \neq j. \tag{3.2}$$

The agents observe each other's gross monetary payoff π_i and exhibit inequity aversion. For convenience, I consider a simplified version of the preferences introduced by Fehr and Schmidt (1999). Specifically, I assume that in each period an agent dislikes outcomes where he is worse off than the other agent. Accordingly, agent i's utility of payoff π_i when his co-worker earns π_j is given by

$$U_i(\pi_i, \pi_j, e_i) = \pi_i - c(e_i) - \alpha \max\{\pi_j - \pi_i, 0\}, \quad i \neq j, \tag{3.3}$$

where $\alpha \geq 0$ denotes his propensity for envy. Thus, the third term captures his disutility derived from disadvantageous inequity.[13]

[12] All workers within the infinite sequence are also homogeneous.

[13] Abstracting from costs, Fehr and Schmidt (1999) propose the following utility function: $U_i = \pi_i - \alpha \max\{\pi_j - \pi_i, 0\} - \beta \max\{\pi_i - \pi_j, 0\}$, $\alpha > \beta > 0$. Incorporating empathy via the parameter $\beta > 0$ would, however, not affect my qualitative results. Allowing for status preferences or pride as reflected by $\beta < 0$ would even strengthen my results. In contrast to my setup and that of Fehr and Schmidt (1999), Demougin and Fluet (2006) take costs into account when investigating inequity aversion: $U_i = \pi_i - c(e_i) - \alpha \max\{\pi_j - c(e_j) - \pi_i + c(e_i), 0\}$. This would also not change my results. However, an inconvenient discontinuity at the symmetric Nash-equilibrium would be introduced.

Compensation contracts may be contingent either on individual contributions or the sum thereof in the respective period.[14] In the *individual bonus scheme*, the principal pays the fixed wage w_I with certainty and promises to pay a bonus b to an agent whenever his individual contribution to firm value in the respective period is favorable ($Y_i = 1$):

Agent $1,2$	$Y_2 = 0$	$Y_2 = 1$
$Y_1 = 0$	$0, 0$	$0, b$
$Y_1 = 1$	$b, 0$	b, b

Thus, agent i's gross monetary payoff is

$$\pi_i = w_I + bY_i. \tag{3.4}$$

In the *group bonus scheme*, the principal offers each agent an identical compensation contract consisting of a guaranteed fixed wage w_G and a (per-agent) group bonus $B_{Y_iY_j}$ which is paid contingent upon both agents' contributions Y_i and Y_j in the respective period. Whenever paid out, the group bonus is paid to both agents. Depending on the contributions' realizations, that contracts allows for the implementation of the following group bonus payments:

Agent $1,2$	$Y_2 = 0$	$Y_2 = 1$
$Y_1 = 0$	$0, 0$	B_{01}, B_{01}
$Y_1 = 1$	B_{10}, B_{10}	B_{11}, B_{11}

Hence, the gross monetary payoff of agent i, $i = 1, 2$, becomes

$$\pi_i = w_G + B_{11}Y_1Y_2 + B_{10}Y_1 (1 - Y_2) + B_{01} (1 - Y_1) Y_2. \tag{3.5}$$

The timing of events in each period is as follows. At the beginning of the period, the principal offers each agent one of the above specified compensation contracts. Second, each agent decides whether to accept the contract or reject it in favor of an alternative employment opportunity that provides utility U_0. Third, if the agents accept the contract, they simultaneously choose their respective effort levels e_i. Fourth, the contributions to firm value Y_i and Y_j are realized and observed by all parties. Finally, the agents receive the explicit fixed wage, and if the contributions to firm value are

[14] That is, I focus on the extreme cases of either a group or an individual incentive scheme without memory.

favorable, the principal decides whether to pay the promised bonuses.

3.3 The Contracts under Verifiable Performance

In this section, I analyze the benchmark case where the agents' contributions to firm value are verifiable. As credibility issues do not arise in this case, I only consider the single-period game.

3.3.1 The Individual Bonus Scheme Revisited

In the following, I briefly characterize the principal-agent problem as analyzed by Kragl and Schmid (2008).[15] Under an individual bonus scheme, from the point of view of one agent, disadvantageous inequity occurs when only the other agent obtains a bonus. As a result, given that his co-worker exerts effort e_j, agent i's expected utility becomes

$$E[U_i|e_i, e_j] = w_I + p\,(e_i)\,b - c\,(e_i) - \alpha(1 - p\,(e_i))p\,(e_j)\,b, \quad i \neq j. \tag{3.6}$$

In such an environment there is a unique symmetric Nash-equilibrium in effort, in the following denoted by e. The shape of $p\,(e)$ and $c\,(e)$ imply a concave payoff function for the agents such that the Nash-equilibrium in effort directly follows from the first-order condition of (3.6):

$$p'\,(e)\,b - c'\,(e) + \alpha p'\,(e)\,p\,(e)\,b = 0 \tag{3.7}$$

As a result, the principal's sets b, w_I, and e to maximize expected profits per agent subject to participation and incentive compatibility constraints:

$$\begin{aligned}
&\max_{b,w_b,e} && (1-b)\,p(e) - w_I \\
&\text{s.t.} && \\
&(\mathrm{IC}_I) && b = \frac{c'\,(e)}{(1+\alpha p\,(e))\,p'\,(e)} \\
&(\mathrm{PC}_I) && w_I + p\,(e)\,b - \alpha(1-p\,(e))p\,(e)\,b \geq c\,(e) + U_0,
\end{aligned} \tag{3.I}$$

where (IC_I) directly follows from (3.7). The equality defines the bonus b which the principal has to offer if she wants to induce effort e. Differentiating with respect to α yields the following result.

[15] For the formal derivation of all results in this subsection see Kragl and Schmid (2008).

Proposition 3.1 *Suppose that performance is verifiable. Then under the individual bonus scheme, holding the agent's effort level constant, the required bonus is decreasing in the agent's propensity for envy.*

Intuitively, as envious agents suffer from being worse off than their co-workers in contrast to non-envious agents, they exert relatively higher levels of effort in order to decrease the probability of not obtaining the bonus. As a result, holding effort constant requires reducing the bonus. This incentive-strengthening impact of envy is in line with the literature.[16] In the remainder of the paper, I will refer to this effect as the *incentive effect*.

The fixed wage w_I negatively enters the principal's objective function such that the participation constraint becomes binding in the optimal contract, leading to zero rent for the agents. Using (IC_I) and (PC_I) in order to substitute w_I and b in the principal's objective function, her problem simplifies to:

$$\max_e \; \left[V_I\left(e;\alpha\right) = p(e) - c\left(e\right) - \alpha p(e)\left(1-p(e)\right)\frac{c'\left(e\right)}{\left(1+\alpha p\left(e\right)\right)p'\left(e\right)} - U_0\right] \tag{3.II}$$

Denote the effort level that maximizes $V_I\left(e;\alpha\right)$ by $e^*\left(\alpha\right)$. Differentiating $V_I\left(e;\alpha\right)$ with respect to α by using the envelope theorem yields the following result regarding the agency costs associated with envy.

Proposition 3.2 *Suppose that performance is verifiable. Then under the individual bonus scheme,*
(i) the first-best solution is obtained if agents are not envious, $\alpha = 0$.
(ii) the first-best solution can never be obtained if agents exhibit a propensity for envy, $\alpha > 0$.
(iii) total agency costs increase as agents become more envious.

In order to ensure participation, the principal needs to compensate envious agents for the expected disutility from payoff inequity. I will refer to this wage cost-augmenting effect of envy as *inequity premium effect*. Again, this result is in line with the agency literature, see e.g. Bartling and von Siemens (2007), Grund and Sliwka (2005), and Neilson and Stowe (2008).

[16] See e.g. Demougin and Fluet (2006) and Neilson and Stowe (2008). In the context of tournaments, Grund and Sliwka (2005) and Demougin and Fluet (2003) report the same result. Kräkel (2008) identifies an incentive-strenghthening effect when emotions play a role in tournaments.

3.3.2 The Group Bonus Scheme

In the group scheme, when exerting effort e_1 while his co-worker exerts effort e_2, agent 1's expected utility is

$$E[U_1|e_1,e_2] = w_G + p(e_1)(1-p(e_2))B_{10} + p(e_2)(1-p(e_1))B_{01} \qquad (3.8)$$
$$+ p(e_1)p(e_2)B_{11} - c(e_1),$$

and for agent 2 accordingly. Under the group bonus scheme inequity in payoffs can never occur such that the agents' inequity-averse preference structure has no effect on their respective utilities. Taking the first-order condition of (3.8) and rearranging terms yields

$$p'(e_1)B_{10} + p'(e_1)p(e_2)(B_{11} - B_{10} - B_{01}) = c'(e_1), \qquad \text{(IC)}$$

with a similar equality for agent 2. Initially, I focus on the symmetric Nash-equilibrium regarding the agents' effort choice. Implicitly, this restricts the bonus scheme such that $B_{10} = B_{01} =: B$. I also define $\Delta := B_{11} - B$. Intuitively, redefining the group bonus scheme in terms of $\{B, \Delta\}$ has a natural interpretation. An agent receives B if at least one agent's contribution to firm value is favorable. That payment differs from the bonus paid if and only if both agents are successful in the amount of Δ. Taking this into account, the incentive-compatibility and participation constraints are for both agents given by:

$$p'(e)B + p'(e)p(e)(\Delta - B) = c'(e) \qquad (\text{IC}_G)$$
$$w_G + 2p(e)B + p(e)^2(\Delta - B) \geq c(e) + U_0 \qquad (\text{PC}_G)$$

Just as in the case of individual bonuses, the fixed wage negatively enters the principal's objective function. Consequently, the participation constraint becomes binding in the optimum. Altogether, the principal has three variables to choose, w_G, Δ, B, and two equations to satisfy, (IC$_G$) and (PC$_G$), such that the following result obtains.

Lemma 3.1 *Suppose that performance is verifiable. Then the principal can implement an arbitrary effort level using any bonus scheme $\{B, \Delta\}$ that satisfies the incentive-compatibility constraint (IC$_G$) for the desired effort level.*

A *group incentive scheme* then implements the following bonus payments depending on the realizations of the agents' respective contributions to firm value:

Agent $1, 2$	$Y_2 = 0$	$Y_2 = 1$
$Y_1 = 0$	$0, 0$	B, B
$Y_1 = 1$	B, B	$B + \Delta, B + \Delta$

Taking this into account, the principal's per-agent profit becomes:

$$\Pi = p(e)(1 - 2B) - p(e)^2(\Delta - B) - w_G \tag{3.9}$$

Substituting w_G from (PC_G), the principal's objective under a group bonus scheme simplifies to:

$$\max_{e,B,\Delta} \quad [V_G(e) = p(e) - c(e) - U_0] \tag{III}$$
$$\text{s.t.} \quad (IC_G)$$

Since, by Lemma 1, the incentive-compatibility constraint can be satisfied for any effort level, the firm implements the first-best solution, e^{FB}:

$$p'(e^{FB}) = c'\left(e^{FB}\right) \tag{3.10}$$

Proposition 3.3 *Suppose that performance is verifiable. Then the first-best solution is obtained for any group bonus scheme $\{B, \Delta\}$ that satisfies (IC_G) for $e = e^{FB}$, regardless of the agents' propensity for envy α.*

Consequently, the initial restriction to a symmetric Nash-equilibrium is without loss of generality.

3.3.3 Comparison of Group and Individual Bonus Scheme

Proposition 3.2 and 3.3 allow for a comparison of the efficiency of the group and the individual scheme in the one-shot game.

Proposition 3.4 *Suppose that performance is verifiable.*
(i) When agents are not envious, $\alpha = 0$, the individual and the group bonus scheme both lead to identical (first-best) profits for the principal.

(ii) When agents are envious, $\alpha > 0$, the principal favors the group scheme over the individual scheme as only the former yields the first-best solution.

With verifiable performance, employing envious agents using an individual bonus scheme comes at a cost for the principal. In contrast, introducing a group bonus resolves the problem as it rules out unequal payoffs; it avoids inequity-premium costs and thus yields the first-best outcome.[17] As I will show in the following, the group incentive scheme, however, requires larger bonus payments. This obtains because a group bonus introduces a free-rider problem with respect to individual effort. As a result, the advantage of the group bonus scheme is weakened once performance is not verifiable.

3.4 The Relational Contracts

In the following, I analyze the moral hazard problem under non-verifiable performance. This requires introducing a credibility constraint for the principal under both incentive schemes. Next I characterize the optimal group contract in the repeated game and compare the results to the individual relational bonus contract.

3.4.1 The Credibility Constraints

To model the relational contract, I embed the foregoing model into an infinitely repeated game between the firm and an infinite sequence of workers, considering trigger strategy equilibria. Specifically, if the principal reneges once on the promised bonus, no agent will ever again believe her to fulfill the contract.[18] Hence, the principal's reputation is decisive for her ability to implement relational contracts. In contrast, since workers are short-lived, reputation effects on their side are not feasible.[19]

[17] As also noted by Englmaier and Wambach (2005), Goel and Thakor (2006), and Bartling (2008), this finding violates the sufficient-statistics result by Holmström (1979). According to that 'informativeness principle', an agent's compensation must depend (only) on those performance indicators that provide incremental information about his action choice. With envious agents and verifiable performance, however, conditioning an agent's incentive pay on his co-worker's performance can be optimal even when the latter provides no information about his effort choice, as is the case in my model.

[18] In deriving the principal's credibility constraint I follow Baker et al. (1994). Implicitly, I assume the information on a principal's deviation from the relational contract to be rapidly transmitted to the labor market. Alternatively, as Baker et al. (1994) note, each period's agent learns the history of play before the period begins. See also Bull (1987) for the role of reputation in relational contracts.

[19] Specifically, allowing for negative bonus payments would create a temptation for the workers to renege on the agreement. When agents live for a bounded number of periods which is known by all

As effort is not observable, agents will exert zero effort if relational contracts are infeasible, corresponding to a closure of the firm and resulting in a fallback profit of zero. If relational contracts are feasible, the principal realizes a continuation profit from each long-term relationship corresponding to the present value of the respective expected one-period profits. Hence, for the relational contract to be self-enforcing, the principal's gains from reneging must fall short of the gains from fulfilling her promise. Specifically, suppose the group scheme $\{B, \Delta\}$ implements effort e in the stage game. Credibility in the repeated game then requires

$$\max\{B, B+\Delta\} \leq \frac{V_G(e)}{r}, \tag{CC$_G$}$$

where r is the firm's interest rate.[20] By contrast, in the individual bonus scheme, for the contracts to be self-enforcing the following condition must hold:

$$b(e;\alpha) \leq \frac{V_I(e;\alpha)}{r} \tag{CC$_I$}$$

Both credibility constraints reveal that, c.p., a small absolute bonus payment and a large expected one-period profit facilitate credible commitment by the principal. In addition, in the individual scheme credibility also depends on the agents' propensity for envy.

3.4.2 The Credibility-constrained Group Bonus Scheme

According to Lemma 3.1, there are many $\{B, \Delta\}$-combinations which implement a desired effort level e. Denote the set of such bonus combinations by $A := \{B, \Delta : p'(e)B + p'(e)p(e)(\Delta - B) = c'(e)\}$. Due to the credibility requirement, however, I focus on that particular scheme $\{B, \Delta\}$ that exhibits the smallest possible bonus payments across all states. In other words, I look for the combination $\{B^*, \Delta^*\}$ imple-

parties, however, the principal can never punish the workers in the last period of the play. As a result, the workers have no reason to resist tempation in that period as withholding the bonus provides them with a payoff larger than their alternative utility. By backward induction, an unraveling effect arises; a negative incentive payment is not credible in any period of the game. Thus, according to observed practice, bonus payments cannot be negative in my setup. For a similar assumption see Baker et al. (1994).

[20]Note that the interest rate r may be interpreted in terms of the firm's discount rate δ. Then $r = (1-\delta)/\delta$, where δ measures e.g. the firm's patience. Hart (2001) emphasizes the discount rate's interpretation as a measure for dependency or trust between the transacting parties. Alternatively, r can be reinterpreted in terms of the likelihood that the firm disappeares from the market, ρ. In that case $r = \rho/(1-\rho)$.

menting effort e such that $\{B^*, B^* + \Delta^*\} = \min_{B, B+\Delta \in A} \max\{B, B + \Delta\}$.

Proposition 3.5 *Suppose that performance is non-verifiable. Then the group bonus scheme that maximizes the range of interest rates r where a given effort level e can credibly be implemented is either $\{B^*, 0\}$ or $\{0, \Delta^*\}$, depending on the value of $p(e)$. Specifically, the principal should choose*

$$\begin{aligned} &\Delta = 0 \text{ and } B^*(e) = \frac{c'(e)}{(1 - p(e))\, p'(e)} \qquad \text{if} \quad p(e) < \tfrac{1}{2}, \\ &B = 0 \text{ and } \Delta^*(e) = \frac{c'(e)}{p(e)\, p'(e)} \qquad \text{otherwise.} \end{aligned} \tag{3.11}$$

Proof. The incentive-compatibility constraint for each agent can be written as

$$(1 - 2p(e))\, B + p(e)\, (B + \Delta) = \frac{c'(e)}{p'(e)}. \tag{3.12}$$

Holding e constant, we obtain

$$\frac{d[B + \Delta(B)]}{dB} = -\frac{1 - 2p(e)}{p(e)}. \tag{3.13}$$

Taking e as given, depending on the value of $p(e)$ we can distingiush two possible cases.

(i) $p(e) < \frac{1}{2}$. Then $d[B + \Delta(B)]/dB < 0$. For implementing e, any increase in B thus implies a reduction of $[B + \Delta(B)]$ and vice versa. As can be seen from Figure 3.1(a), solving for $\min\max\{B, B + \Delta(B)\}$ requires $B = B + \Delta(B)$ or $\Delta = 0$. Finally, B^* follows from (3.12):

$$B^*(e) = \frac{c'(e)}{(1 - p(e))\, p'(e)} \tag{3.14}$$

(ii) $p(e) \geq \frac{1}{2}$. Then $d[B + \Delta(B)]/dB \geq 0$. Thus, for implementing e, any reduction of B implies a reduction in $[B + \Delta(B)]$ and vice versa (see Figure 3.1(b)). Hence, the principal should set B as small as possible s.t. $B \geq 0$, yielding $B = 0$ and

$$\Delta^*(e) = \frac{c'(e)}{p(e)\, p'(e)}. \tag{3.15}$$

■

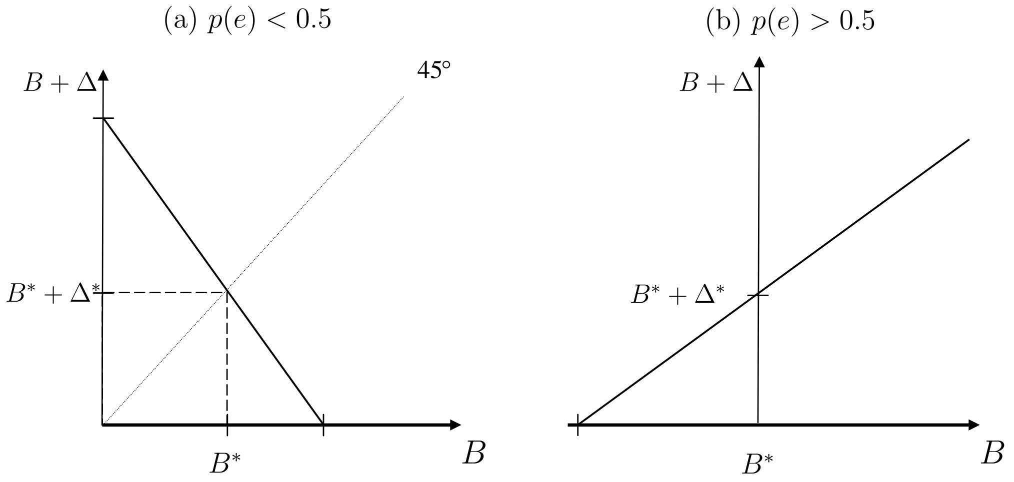

Figure 3.1: The incentive-compatibility constraint under a group bonus scheme with (a) $p\,(e) < 0.5$ and (b) $p\,(e) < 0.5$

The foregoing suggests an interesting observation regarding the group scheme. Suppose under verifiability the first-best effort level yields a success probability $p\left(e^{FB}\right) \geq \frac{1}{2}$. Under non-verifiability, the principal would want to maximize the range of interest rates where e^{FB} can be credibly implemented. Accordingly, she would choose to pay a group bonus only if both agents are successful; Δ^*. However, if her interest rate is large, she may be forced to lower the effort level in order to satisfy the credibility constraint. Now suppose that the constraint requires such a strong reduction in effort that $p\,(e) < \frac{1}{2}$. Then the principal would switch from the reward that is paid only if both are successful to the bonus paid if at least one agent is successful; B^*.

3.4.3 Comparison of Group and Individual Bonus Scheme

3.4.3.1 Group vs. Individual Bonus

According to Proposition 3.5, when implementing effort e under a group bonus scheme, the principal pays a group bonus $B = B^*\,(e)$ whenever at least one of the agents is successful ($p\,(e) < \frac{1}{2}$), or she pays $\Delta = \Delta^*\,(e)$ only in the case where both agents are successful ($p(e) \geq \frac{1}{2}$). I summarize this result in the following tables:

Optimal group scheme if $p(e) < \frac{1}{2}$		
Agent i, j	$Y_j = 1$	$Y_j = 1$
$Y_i = 0$	$0, 0$	B, B
$Y_i = 1$	B, B	B, B

Optimal group scheme if $p(e) \geq \frac{1}{2}$		
Agent i, j	$Y_j = 0$	$Y_j = 1$
$Y_i = 0$	$0, 0$	$0, 0$
$Y_i = 1$	$0, 0$	Δ, Δ

From the optimization problem (3.I) derived in section 3.3.1 we know that, in order to induce effort level e under the individual incentive scheme, the required bonus depends on the agents' propensity for envy and is given by

$$b(e;\alpha) = \frac{c'(e)}{(1+\alpha p(e))\, p'(e)}. \tag{3.16}$$

Comparing equations (3.11) and (3.16) yields the following result.

Proposition 3.6 *For any given effort level* e *and any propensity for envy* $\alpha \geq 0$*, the size of the incentive-compatible group bonus exceeds the size of the individual bonus. Moreover, the relative difference between the two incentive payments is increasing in* α*.*

Proof. Consider the case $p(e) \geq \frac{1}{2}$. Equations (3.11) and (3.16) imply:

$$\Delta^*(e)\frac{p(e)}{1+\alpha p(e)} = b(e;\alpha) \quad \Longrightarrow \quad \Delta^*(e) > b(e;\alpha) \tag{3.17}$$

Moreover, the difference is

$$\Delta^*(e) - b(e;\alpha) = \Delta^*(e)\left(1 - \frac{p(e)}{1+\alpha p(e)}\right), \tag{3.18}$$

which is decreasing in α. Similarly, for the case $p(e) < \frac{1}{2}$ the equations yield:

$$B^*(e)\frac{1-p(e)}{1+\alpha p(e)} = b(e;\alpha) \quad \Longrightarrow \quad B^*(e) > b(e;\alpha) \tag{3.19}$$

Again, solving for the difference verifies that it is decreasing in α. ■

Intuitively, the group bonus introduces a positive externality effect of an agent's effort on his co-worker's expected payoff. As a result, for the group scheme the probability of obtaining the bonus is less responsive to changes in one's effort than in the individual contract. Hence, the group bonus must be larger in order to elicit the same effort level. Moreover, due to the incentive effect of envy identified above, the individual bonus becomes smaller the more envious the agents. In contrast, the group bonus is not affected by variations in α, so that the difference between the two is increasing.

3.4.3.2 Profitability

By Proposition 3.4, as long as the principal faces no credibility problem, the group bonus contract (weakly) dominates the individual bonus scheme. In this subsection, I reexamine the conclusion when credibility plays a role. In order to do so, I study the effects of envy on the principal's profits in the repeated game.

In the repeated framework, an optimal relational contract implements the effort level that maximizes the principal's expected profit per period and agent, subject to her credibility constraint. Hence, the optimal profit in the *individual scheme* is

$$V_I^*(r,\alpha) := \max_e V_I(e;\alpha) \quad \text{s.t.} \quad b(e;\alpha) \leq V_I(e\,;\alpha)/r. \tag{3.20}$$

Accordingly, optimal profit in the *group scheme* is given by[21]

$$V_G^*(r) := \max_e V_G(e) \ \text{ s.t. } \ \min\{B^*(e), \Delta^*(e)\} \leq V_G(e)/r, \quad (\mathrm{IC}_G). \tag{3.21}$$

Next I define the critical interest rates for which the principal can just implement the same contract as under verifiability. Specifically, for the group bonus scheme with verifiable performance, the principal implements the first-best effort level, e^{FB}. Thus, I define $\underline{r_G}$ s.t. $\min\{B^*\left(e^{FB}\right), \Delta^*\left(e^{FB}\right)\} = V_G\left(e^{FB}\right)/\underline{r_G}$. Similarly, under an individual bonus scheme, under verifiability the principal implements effort $e^*(\alpha)$. Denote with $\underline{r_I}(\alpha)$ the interest rate where $b(e^*(\alpha);\alpha) = V_I(e^*(\alpha)\,;\alpha)/\underline{r_I}(\alpha)$.

Under both incentive schemes, adapting the implemented effort level e in order to satisfy the respective credibility constraints allows the principal to stay credible for a range of interest rates $r > \underline{r_G}$ and $r > \underline{r_I}(\alpha)$, respectively. For sufficiently high interest rates, however, the credibility constraint can no longer be satisfied; relational contracts become infeasible. Denote the interest rates for which this is the case under the two

[21] By Proposition 3.5, the principal pays either $B^*(e)$ or $\Delta^*(e)$. Note that, depending on the value of $p(e)$, she implements the smaller of these bonus payments.

incentive regimes $\overline{r_G}$ and $\overline{r_I}(\alpha)$, respectively. Moreover, I designate the effort level just implementable in an individual bonus scheme for $\overline{r_I}(\alpha)$ by $\overline{e_I}$.

Non-envious Agents

For expository purposes, I first consider the case $\alpha = 0$. If so, there are no inequity-premium costs under either incentive scheme. Consequently, expected one-period profits coincide for any effort level e; $V_G(e) = V_I(e; 0)$. However, the group bonus exceeds the individual bonus for any e; $b(e; 0) < \min\{B^*(e), \Delta^*(e)\}$. Thus, the principal is able to credibily implement a given effort level for a greater range of interest rates under the individual bonus scheme, yielding the following result.

Proposition 3.7 *Suppose that performance is non-verifiable and agents are not envious, $\alpha = 0$. Then the principal always (weakly) prefers the individual bonus contract to the group bonus contract.*

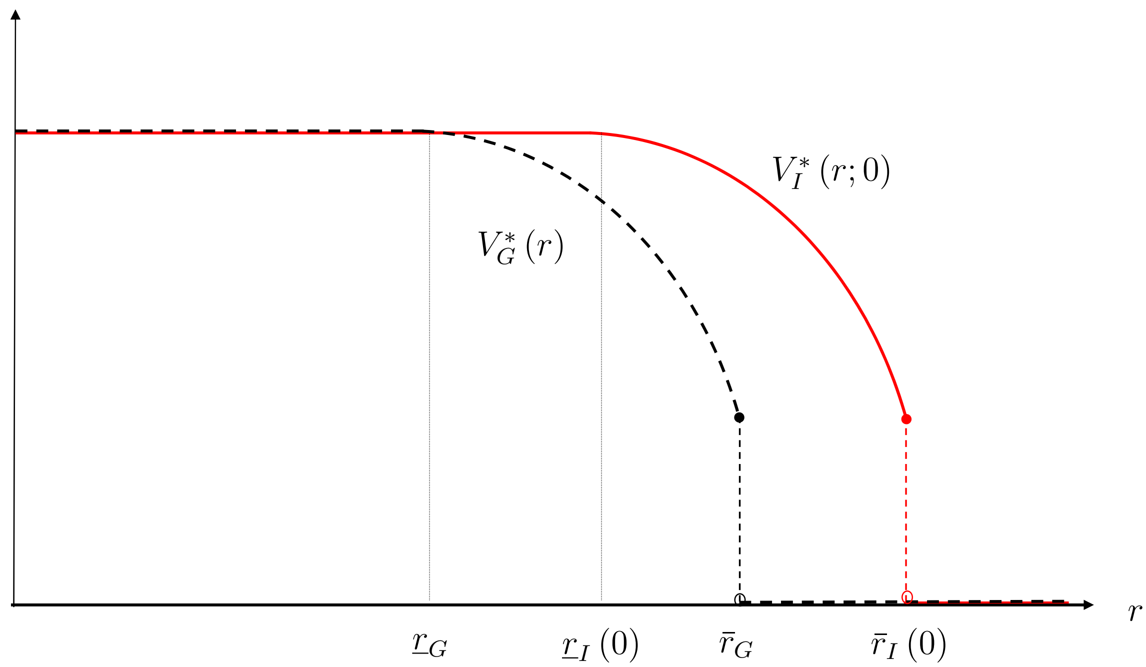

Figure 3.2: Profits under non-verifiable performance in the individual and the group bonus scheme with non-envious agents

Figure 3.2 illustrates this result.[22] I therein sketch the firm's profit in the repeated

[22]Figure 3.2 and all subsequent figures are drawn for the case in which $p\left(e^{FB}\right) < \frac{1}{2}$, thus for the group bonus $B^*(e)$. With $p\left(e^{FB}\right) \geq \frac{1}{2}$, the principal might switch from $\Delta^*(e)$ to $B^*(e)$ for large interest rates as discussed above. This would induce a kink in the profit path under the group scheme which, however, does not affect any of the results.

game, depending on her interest rate. The dashed curve depicts the profit using a group bonus whereas the solid curve depicts the profit under an individual scheme. As long as none of the credibility constraints is binding, profits are equal under either scheme, implementing the first-best outcome. Since $b(e;0) < \min\{B^*(e), \Delta^*(e)\}$, the constraint becomes binding first under the group scheme, i.e. $\underline{r_G} < \underline{r_I}(0)$. Under either contract, profits decrease as r further increases since credibly implementable effort levels veer away from e^{FB} and $e^*(0)$, respectively. As derived above, the interest rate, for which a given e can be implemented, is always larger under the individual contract. Consequently, that contract is feasible for a greater range of interest rates, i.e. $\overline{r_G} < \overline{r_I}(0)$. Altogether, profits under the individual bonus scheme exceed profits in the group scheme for any interest rate $\underline{r_G} < r \leq \overline{r_I}(0)$. Hence, when agents are not envious and credibility is an issue, the principal clearly prefers the individual bonus scheme.

Envious Agents

Compared to the foregoing situation, an increase in the agents' propensity for envy has no impact on the firm's profits under the group scheme, $V_G^*(r)$, but it shifts the profit curve under an individual contract, $V_I^*(r;\alpha)$, downwards in a continuous way. As a result, for a range of sufficiently small interest rates, the situation resembles that under verifiability; the principal is better off using a group bonus. For small variations in α and sufficiently large interest rates, however, the individual scheme in fact dominates the group scheme. Geometrically, this is represented in Figure 3.3. If $V_I^*(r;\alpha)$ shifts downwards, it must intersect $V_G^*(r)$ for small variations in α, i.e. there is an interest rate $\widehat{r}(\alpha)$ such that $V_I^*(r;\alpha) = V_G^*(r)$. Thus, by continuity of the profit functions, for any $r > \widehat{r}(\alpha)$, the principal must be at least as well off with an individual bonus as with a group bonus and absolutely better off for a range of interest rates $\widehat{r}(\alpha) < r \leq \overline{r_I}(\alpha)$.

The above intuition, however, does not automatically extend to large variations in α. This is due to fact that with increasing α, the upper interest threshold $\overline{r_I}(\alpha)$ may either decrease or increase, depending on the parameters. If the latter is the case, then it holds that $\overline{r_G} < \overline{r_I}(\alpha)$ for any α, and the above result indeed carries over to arbitrary variations in the agents' propensity for envy. Kragl and Schmid (2008) provide a condition for which $\overline{r_I}(\alpha)$ in fact increases in α.[23] Under that condition it must hold that $\overline{r_I}(\alpha) - \overline{r_G}$ is positive and increasing in α. Consequently, for a range of interest rates $\widehat{r}(\alpha) < r \leq \overline{r_I}(\alpha)$ and for any α, the principal clearly favors the

[23] See chapter 2, proof of Proposition 2.3.

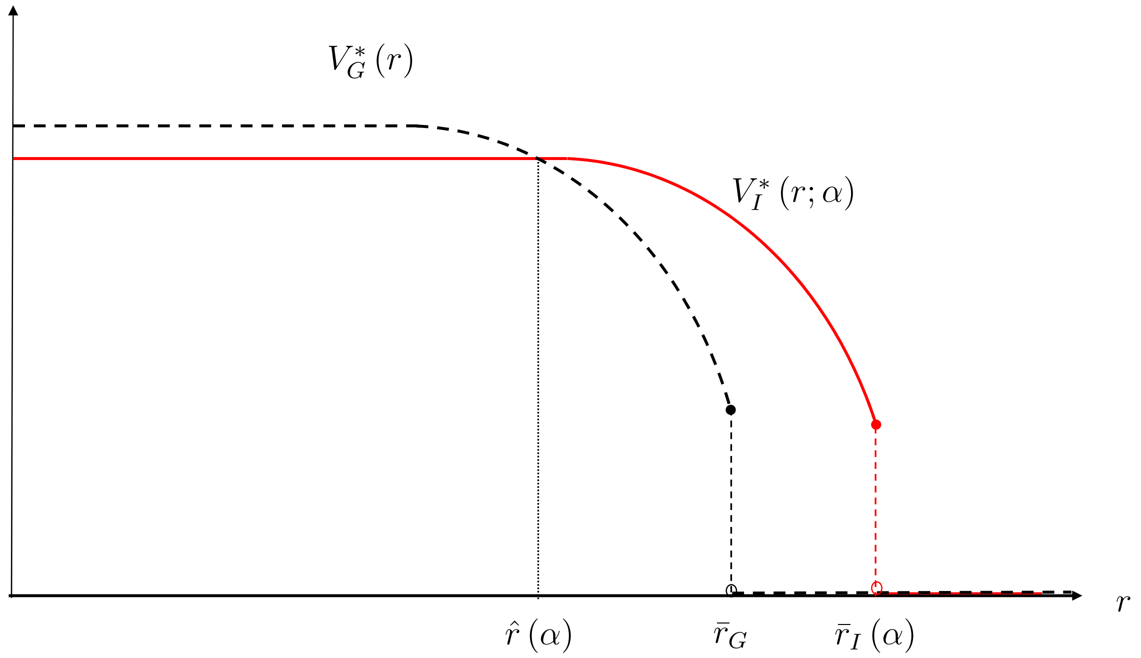

Figure 3.3: Profits under non-verifiable performance in the individual and the group bonus scheme with envious agents, given that $\alpha > 0$ is sufficiently small

individual bonus scheme over the group scheme. I summarize the above results in the following proposition.

Proposition 3.8 *Suppose that performance is non-verifiable. Then there are combinations of the agents' propensity for envy α and interest rates r for which the individual bonus scheme is more profitable than the group bonus scheme if and only if*
(i) the agents are not too envious, i.e. α is sufficiently small, or
(ii) the following condition is satisfied at the marginal implementable effort level $e = \overline{e_I}$:

$$p(e) > \frac{(c(e) + U_0)\, p'(e) + c'(e)}{p'(e) + c'(e)} \tag{3.22}$$

Intuitively, the above result obtains because the individual bonus scheme rules out free-rider problems and moreover benefits from the incentive effect of envy. Hence, c.p. reneging on the relational contract is less attractive for the firm under the individual bonus scheme, and thus credibility is facilitated by the impact of envy. The individual bonus scheme, however, imposes inequity-premium costs on the firm. For a given level of effort and a positive degree of envy, expected one-period profits are consequently larger in the group scheme. Hence, fulfilling the relational contract is c.p. less attractive for the firm under the individual bonus scheme, and credibility is more difficult due to the impact of envy.

Altogether, the prospect of unequal pay has an ambiguous effect on the principal's ability to credibly commit to the relational contract when agents are envious. Whenever the principal's incentive to renege on the (relatively small) individual bonus payments is sufficiently low such that the negative impact of envy on the continuation profit is overbalanced, the individual bonus scheme enhances credibility and is thus superior for high interest rates (see Figure 3.4). This is guaranteed by condition (3.22). Intuitively, the inequation requires the continuation profit $V_I(e; \alpha)$ to react less strongly to an increase in the degree of envy than the bonus payment $b(e; \alpha)$. From the condition can further be inferred, that the credibility-enhancing effect is more likely to arise if the precision of the performance measure is large and the effort elasticity of costs is small.[24]

In summary, the foregoing analysis reveals that there exist cases where reputational equilibria can be sustained for a greater range of interest rates under the individual bonus scheme. The principal then favors the individual bonus contract over the group bonus contract if her interest rate is sufficiently large. Surprisingly, this result not only obtains because of the free-rider problem under a group bonus scheme but also due to the agents' distaste for wage inequality. Concluding, the different findings of this subsection are illustrated by Figure 3.4.

3.5 Concluding Remarks

In the existing literature on incentive contracts it is commonly assumed that concerns for equity or fairness could serve as an explanation for observed wage compressions or the absence of individual performance pay. The present paper shows that this prediction is certainly valid when incentives are contingent on verifiable performance, but should be qualified once performance measures are not verifiable. Specifically, when the incentive contracts are enforced as reputation equilibria in a repeated game, an individual bonus scheme may be more profitable than a group bonus scheme though the former allows for unequitable payoffs which the agents dislike.

This main result emerges from the fact that, with non-verifiable performance, incentive contracts must be self-enforcing which requires a repeated relationship in which

[24]For a more detailled discussion of condition (3.22) and formal derivations see chapter 2.

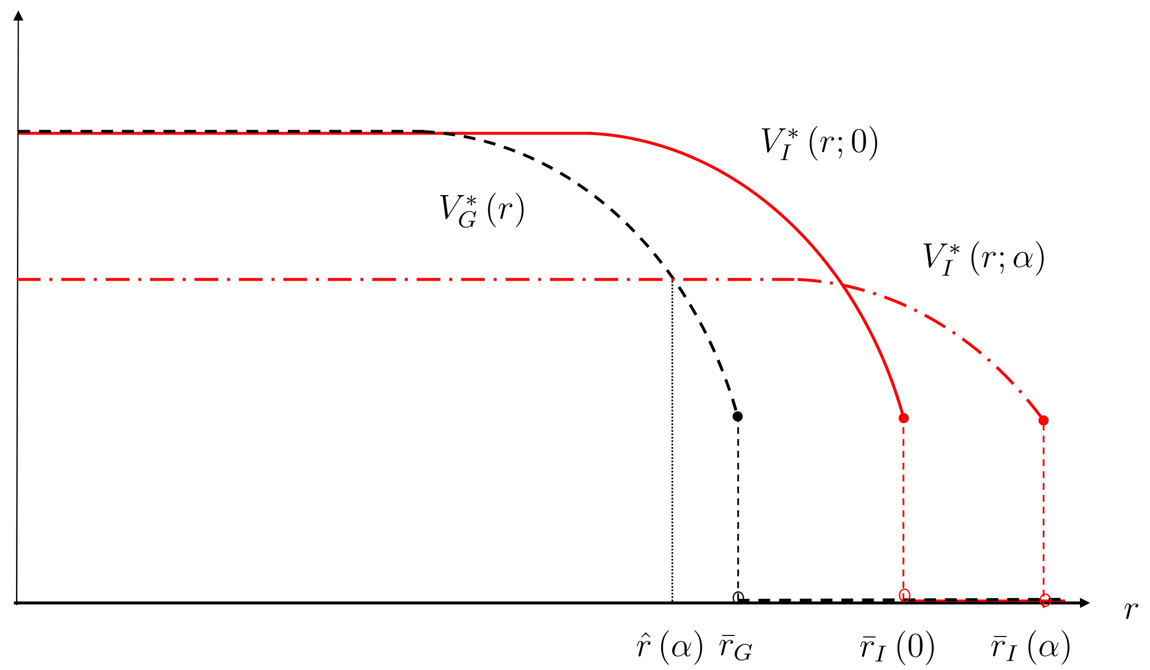

Figure 3.4: Profits under non-verifiable performance in the individual and the group bonus scheme with envious agents, provided that condition (3.22) is satisfied

the principal is credible to pay a promised reward for good performance. The latter is the case if the principal's gains from reneging fall short of the discounted gains from continuing the contract. Thus, credible commitment becomes less likely if the firm's discount rate is small (and her interest rate is large respectively).[25] As regards the design of the incentive scheme, high bonus payments as well as small expected firm profits impede credibility. In the present paper, I analyze the incentive provision in an infinitely repeated game of one firm and two workers who have a distaste for earning less than their respective co-worker. Specifically, I compare the profitability of two distinct incentive regimes; individual bonus contracts and group bonus contracts. The analysis reveals that the two schemes exhibit converse forces regarding the principal's credibility and thus her profits in the repeated employment relationship.

I find that the group bonus contract is superior for large discount rates whereas the individual bonus scheme may become advantageous when the firm's discount rate is small. In the former case, the firm implements the first-best outcome as inequity-premium costs do not arise under a group bonus contract. For small discount rates,

[25] For expository purposes, in the introduction and the conclusion I use the term discount rate which is, of course, inversely related to the firm's interest rate.

however, credibility becomes an issue and using an individual bonus scheme may become optimal. This is due to the fact that, in order to induce a given level of effort, the individual scheme requires smaller bonus payments than the group scheme, thereby enhancing the firm's credibility. This obtains because the individual scheme avoids free-rider problems and moreover exploits the incentives associated with unequal pay. The individual bonus scheme, however, also exhibits a negative impact on the firm's credibility as it implies inequity-premium costs and, consequently, lowers the expected benefits from contract continuation. Whenever the credibility-enhancing effect is stronger, the principal is better off using an individual bonus scheme if her discount rates is sufficiently small.

Altogether, I show that there are combinations of inequity aversion and discount rates for which the relational individual bonus contract is more profitable than the group bonus contract. Moreover, there are cases where the group contract becomes yet infeasible whereas the individual bonus contract still yields positive profits. Interpreting the firm's discount rate as a measure of the life span of a firm's employment at the market, my findings suggest that, with non-verifiable performance and inequity averse agents, group incentives are optimal for long-term employment whereas individual incentives may become optimal when employment is of short duration.[26] This complements the findings of Che and Yoo (2001) who derive a similar result driven by peer pressure with respect to individual effort choice.

It is worth briefly discussing some assumptions of my model. First, as regards the agents' preferences, I have focused on envy. My results, however, extend to the case of also compassionate agents as proposed by Fehr and Schmidt (1999). This is due to the fact that the characterization of inequity aversion implies the extent to which agents dislike being outperformed to exceed the extent to which they resent being ahead; $\alpha > \beta$. In fact, my findings are strengthened when agents exhibit preferences for status or pride as reflected by assuming $\beta < 0$.[27] Status seeking leads to even stronger incentives on the one hand and acts contrary to the expected disutility from being behind on the other hand, thereby increasing profits.[28] As a result, credibility of the firm is unambiguously facilitated by this kind of preferences. Altogether, my results

[26]Allowing for infinitely long-lived workers, this result directly transfers to the life span of the individual employment relationship.

[27]For evidence on this kind of preferences see e.g. Loewenstein et al. (1989) and Moldovanu et al. (2007).

[28]Note that for the case $\beta < 0$ and $\alpha < |\beta|$, the principal can exploit the agents' other-regarding preferences in such a way that profits even exceed first-best profits.

are supported for a preference structure which is also known as 'behindness aversion' (see e.g. Neilson and Stowe, 2008).

Second, throughout the analysis, I have assumed that agents are not financially constrained. Dropping this assumption, however, would reinforce my results. Due to the large bonus payments, the group scheme then becomes expensive for the principal in terms of the rents left to the agents. This reduces continuation profits and thus makes credibility more difficult. Individual bonus contracts, in contrast, allow for smaller incentive payments and consequently imply smaller rents. The resulting larger continuation profit favors credibility. Hence, for large discount rates, the advantage of the group scheme is weakened. For small discount rates, the beneficial effect of envy on the firm's credibility becomes even stronger.

Third, it is worth pointing out that I have restricted the analysis to the extreme cases of pure individual and group bonus schemes. When credibility becomes an issue such that the first-best group bonus is no longer credible, the principal could alternatively pay some amount of individual bonus in addition to a reduced group bonus in order to lower the absolute incentive payment. Concerning the principal's credibility, however, I expect the basic trade-offs identified in the present paper to carry over to such a combined bonus scheme. Again, the incentive effect of envy favors credibility whereas the dissatisfaction associated with the prospect of unequal pay makes it more diffcult. Compared to the pure bonus schemes analyzed in this paper, both effects' magnitude would certainly be smaller. As the individual bonus scheme, however, not only involves an incentive effect but also solves the free-rider problem, there may exist intermediate discount rates for which a combined bonus scheme could be superior. Nevertheless, for non-intermediate discount rates, my results would reestablish. Specifically, for small discount rates, only a pure individual bonus contract alleviates or yet guarantees credibility.

Concluding, my findings underline that empirically observed cultural differences in social preferences should not be neglected in organizational decisions. For example, Alesina et al. (2004) and Corneo (2001) find Europeans to exhibit a higher propensity for inequity aversion in comparison to U.S. Americans. In a recent empirical cross-country investigation, Isaksson and Lindskog (2007) find that Swedish, Hungarian, and German people are more supportive of redistribution than U.S. Americans. The existing theoretical literature suggests that these social differences play a crucial role for the design of incentive schemes. In particular, when performance is verifiable, inequity averse preferences may render team incentives optimal. The present analysis suggests that opposed implications may result for those occupations for which performance is not verifiable and firms thus have to rely on self-enforcing agreements.

Chapter 4

Individual vs. Relative Performance Pay with Envious Workers and Non-Verifiable Performance

In a moral-hazard environment, I compare the profitabilities of a rank-order tournament and independent bonus contracts when a firm employs two envious workers whose individual performances are not verifiable. Whereas the bonus scheme must then be self-enforcing, the tournament is contractible. Yet the former incentive regime outperforms the latter as long as credibility problems are not too severe. This is due the fact that the tournament requires unequal pay across peers with certainty, thereby imposing large inequity premium costs on the firm. For a simple example, I show that the more envious the agents are, the larger is the range of interest rates for which the bonus scheme dominates the tournament.

4.1 Introduction

Rank-order tournaments are highly competitive incentive schemes based upon relative performance.[1] They are suitable for mitigating moral hazard problems and for the selection of agents under uncertainty about the agents' talents. In the present paper, I focus on the first issue. Compared to other incentive schemes, an important advantage

[1]Tournaments have been extensively discussed in the literature since the seminal article by Lazear and Rosen (1981). See e.g. Nalebuff and Stiglitz (1983), Malcomson (1984), Malcomson (1986), O'Keeffe et al. (1984), or Bhattacharya and Guasch (1988).

of tournaments is their contractibility in situations where an agent's performance is only known to the principal.[2] This is due to the fact that the particular outcome of the tournament has no impact on total wage costs because the principal credibly commits to a fixed prize structure ex ante.[3] However, pitting workers against each other confronts contestants with the certainty of unequal payoffs between peers. Workers though care for relative payoffs as suggested by empirical evidence.[4] In particular, they frequently exhibit a distaste for inequitable payoff distributions. The prospect of unequal pay then implies additional agency costs for the firm, the so-called inequity premium. In a tournament, these costs cannot be avoided.[5]

By contrast, under individualistic incentive schemes, inequity premium costs are smaller as payoff inequity does not always occur but only with some positive probability. If the individual signals about the workers' performance are, however, not contractible, a double-sided moral hazard problem arises. Specifically, the principal can save wage costs by understating a worker's performance ex post. Workers anticipate the principal's opportunistic behavior and are not willing to work hard. However, given that the contracting parties observe the agent's performance, incentive contracts may yet be sustained in long-term relationships as reputational equilibria.[6] Such agreements are called relational (or implicit) contracts. Since they are not court-enforceable, the incentive contracts must be self-enforcing.

The purpose of this paper is to compare the aforementioned prominent incentive schemes given that performance measures are non-verifiable and workers are concerned with relative payoffs. Specifically, I analyze the trade-off between the agency costs due

[2]Third parties, as e.g. a court, are often not able to verify each piece of information that is available to the principal. Moreover, it will often be too costly or even impossible to credibly communicate the agent's contribution to firm value to an outside party. See e.g. Milgrom and Roberts (1992) and Holmström and Milgrom (1994).

[3]See e.g. Malcomson (1984, 1986). Other advantages of tournaments include the low measurement costs since relative comparisons are often easier to make than absolute judgements. Moreover, random factors that affect all agents equally are automatically filtered such that the risk premium can be lowered without affecting incentives. These issues are, however, not considered in the present paper.

[4]See e.g. Goranson and Berkowitz (1966), Berg et al. (1995), and Fehr et al. (1998). For an overview of the experimental literature on other-regarding preferences see Camerer (2003) or Fehr and Schmidt (2006).

[5]Tournaments may also induce sabotage activities or collusion. Moreover, once intermediate results are known effort incentives are strongly reduced. These problems are, however, not the subject of the present paper.

[6]Reputational equilibria may exist if one party cares about her reputation in future relationships. In particular, the parties may prefer to stick to the implicit agreement if there is a credible future punishment threat in case they renege on the agreement. See e.g. Holmström (1981), Bull (1987), or Baker et al. (1994, 2002).

to the self-enforcement requirement under a bonus scheme and those due to inequity aversion under a tournament contract. Moreover, I analyze the impact of inequity aversion on the relative profitability of the incentive regimes.

Formally, I analyze an infinitely repeated game between a long-lived firm and a sequence of two homogeneous short-lived workers. The latter are consigned to work on a similar task which is valuable for the firm.[7] Following Fehr and Schmidt (1999), workers exhibit 'self-centered inequity aversion'. Inequity is specified as inequality, which is suitable provided that agents face symmetrical decision environments. Moreover, I abstract from empathy, which does not affect my qualitative results however. An agent's performance is difficult to measure in the sense that neither is his contribution to firm value observable nor exists a contractible signal on it. But the contracting parties observe an imperfect non-verifiable continuous signal of each worker's effort. To mitigate the moral hazard problem, the firm offers the workers either a rank-order tournament or an individual bonus contract. In the tournament, the agent with the best performance is awarded a winner prize whereas the other receives the smaller loser prize. Under the bonus scheme, an agent obtains a bonus if his performance measure meets or exceeds an ex ante specified standard. In order to guarantee self-enforcement of the bonus contracts, reputation concerns have to restrain the firm from deviating. Specifically, credibility requires the firm's gains from reneging on the bonus to fall short of the discounted profits from continuing the contract (see e.g. Baker et al., 1994).

Given the two incentive regimes, I first determine the principal's cost of inducing arbitrary levels of effort. Then I deduce the relative profitability of the contracts. I find that the bonus scheme outperforms the tournament for a range of sufficiently small interest rates. This is due to the fact that the latter incentive contract imposes large inequity premium costs on the firm by virtue of a high degree of income inequality. In contrast, the bonus contract entails less expected payoff inequity rendering it superior as long as credibility problems are not too severe. For sufficiently large interest rates, however, credibility requirements restrict the set of implementable effort levels thereby reducing profits. Thus, the firm switches to the tournament contract once the interest rate is such that profits under both schemes coincide.

Moreover, I investigate the impact of a variation in the agents' inequity aversion on the result. For a simple example, I show the range of interest rates for which the

[7]Typically, workers in such a situation tend to compare their payoffs with those of their colleagues. For the importance of reference groups, see e.g. Loewenstein et al. (1989).

bonus scheme is superior to the tournament to be increasing in the agents' propensity for envy. Intuitively, envy affects both incentive regimes differently. Profits in the tournament clearly decrease as agents become more envious. By contrast, envy has an ambiguous impact on the credibility constraint and, thus, on the resulting profits under the bonus scheme. One the one hand, credibility is favored since envy has an incentive-strengthening effect that allows for lowering the bonus and thus reduces the firm's incentive to cheat. On the other hand, the inequity premium is increasing in the agents' propensity for envy which lowers continuation profits and, consequently, makes credibility more difficult. Altogether, I find that envy benefits the dominance of the bonus contract.

Overall, my findings underline that empirically observed cultural differences in social preferences have non-negligible implications for the optimal design of incentive contracts. In particular, the impact of other-regarding preferences proves to be sensitive to the verifiability of the underlying performance measures. When agents have fairness concerns, individualistic pay schemes clearly outperform tournaments given that performance is verifiable. When performance signals are not verifiable, the result is reversed for purely selfish agents. For envious agents, however, individual performance pay becomes again superior for a considerable range of interest rates even if performance is not verifiable. This result is strengthened the more envious the agents become.

The present paper brings together important aspects of the literature on tournaments, relational contracts, and that on inequity aversion. In their seminal papers, Lazear and Rosen (1981) and Green and Stokey (1983) also compare relative and independent incentive contracts but consider a static environment with purely self-interested agents. The latter authors propose an output function involving a multiplicative common shock. Similarly, I use a multiplicative individual shock in modeling the performance signal. Related to my approach, other papers as e.g. Malcomson (1984, 1986) emphasize the enforceability advantage of tournaments. The present study offers a complementary, preference-dependent explanation as to why either individual pay schemes or tournaments may be superior in repeated employment settings.

The enforceability of incentive schemes under non-verifiable performance is the subject of the literature on relational contracts. Earlier contributions have focused on environments with symmetric information, e.g. Bull (1987), MacLeod and Malcomson (1989), and Levin (2002). More recent papers analyze self-enforcing contracts under moral hazard in effort, e.g. Baker et al. (1994, 2002), Levin (2003), and Schöttner (2008)). Similar to my work, some papers compare the efficiency of different incentive regimes for multiple agents (Che and Yoo, 2001; Kvaløy and Olsen, 2006, 2007). I contribute to that strand of literature by additionally introducing fairness concerns among agents.

During the last decade, there is an evolving literature linking standard incentive theory and social preferences.[8] Much of the work is associated with the impact of inequity aversion on individual incentive contracts under verifiable performance. Moreover, as I do, the majority of papers focuses on mutually inequity averse agents, e.g. Demougin et al. (2006), Bartling and von Siemens (2007), and Neilson and Stowe (2008).[9] The effects of such preferences on tournaments are analyzed by Demougin and Fluet (2003), Grund and Sliwka (2005), and Schöttner (2005).[10] More closely related to my analysis are those papers that compare the efficiency of various performance-pay schemes for other-regarding workers , e.g. Bartling (2008), Rey-Biel (2008), Goel and Thakor (2006), and Itoh (2004). I complement this literature by extending the analysis of different incentive regimes for mutually inequity averse agents to non-verifiable performance measures.

Most closely related to the present paper is the study by Kragl and Schmid (2008), who find that inequity aversion may enhance the profitability of individual relational incentive contracts.[11] In that paper, we also briefly discuss rank-order tournaments and give the intuition for a comparison with the individual payment scheme. The basic model of that paper, however, solely encompasses binary performance measures, which does not allow to satisfactorily embed the results into the standard literature on tournaments. Thus, the present paper complements the former by introducing continuous performance signals and presenting a rigorous analysis of the two incentive schemes in such an environment.

The paper proceeds as follows. The next section describes the basic economic framework. Section 4.3 introduces the rank-order tournament, and Section 4.4 derives the optimal individual bonus scheme. In Section 4.5, I compare the profitabilities

[8] Alternative approaches regarding the formalization of other-regarding preferences have been proposed, e.g. by Rabin (1993), Fehr and Schmidt (1999), Bolton and Ockenfels (2000), and Falk and Fischbacher (2006).

[9] Englmaier and Wambach (2005) and Dur and Glazer (2008) examine incentive contracts when agents care about inequality relative to the principal.

[10] More generally, Kräkel (2008) analyzes the role of emotions in tournaments.

[11] This paper is presented in chapter 2 of the present thesis.

of the two incentive regimes and investigate the impact of a variation in the agents' propensity for envy on the results. Section 4.6 offers some concluding remarks.

4.2 The Model

I consider an infinitely repeated game between a long-lived firm, hereafter the principal, and a sequence of two homogeneous short-lived workers, hereafter the agents $i = 1, 2$.[12] In each period, each of the two agents undertakes costly unobservable effort $e_i \geq 0$ that generates some value $v(e_i)$ for the principal. The value function is increasing and concave. An agent's private cost of effort is a strictly increasing and strictly convex function $c(e_i)$ with $c(0) = 0$. Moreover, $c(e_i)$ is twice differentiable for all $e_i > 0$ and $c'(0) = 0$.

An agent's performance is difficult to measure in the sense that neither his contribution to firm value $v(e_i)$ can be observed nor exists a verifiable signal on it. The contracting parties observe, however, a noisy non-verifiable performance measure x_i for each agent:

$$x_i = e_i \varepsilon_i, \quad i = 1, 2, \tag{4.1}$$

where ε_i is an individual random component. The random components of both agents are independent and identically standard uniformly distributed; $\varepsilon_i \overset{iid}{\sim} U(0, 1)$. In other words, effort is measured in terms of the largest possible realization of the performance measure given the amount of work undertaken by the agent.

The agents observe each other's gross wage π_i and exhibit inequity aversion concerning the wage payments.[13] For convenience, I consider a simplified version of the preferences introduced by Fehr and Schmidt (1999). Specifically, I assume that in each period an agent dislikes outcomes where he is worse off than his colleague. Accordingly, in each period agent i's utility of payoff π_i when his co-worker earns π_j is given by

$$U_i(\pi_i, \pi_j, e_i) = \pi_i - c(e_i) - \alpha \max\{\pi_j - \pi_i; 0\}, \quad i \neq j, \tag{4.2}$$

where $\alpha \geq 0$ denotes his propensity for envy. Thus, the third term captures his disutility derived from disadvantageous inequity.[14]

[12] Workers in the sequence are also homogeneous over time.

[13] Note that dropping the assumption of observable wages would not nesessarily resolve the problem of inequity aversion. Agents usually have a belief of a close colleague's income and can moreover infer on wages from observable signals on wealth.

[14] Abstracting from costs, Fehr and Schmidt (1999) propose the following utility function: $U_i = \pi_i -$

The sequence of events in each period is as follows. At the beginning of the period, the principal offers both agents one of two compensation contracts; either a rank-order tournament or an individual bonus contract. Second, each agent individually decides whether to accept the contract or reject it in favor of an alternative employment opportunity that provides utility $\bar{u} \geq 0$. Third, if the agents accept the contract, they simultaneously choose their respective effort levels. Fourth, contributions to firm value are realized and the individual performance measures are observed by all contracting parties. Finally, wage payments are made.

4.3 The Tournament Contract

In the rank-order tournament, in each period the principal ex ante commits to paying out a fixed sum of wages $w + l$. The two agents compete for the winner prize $w > l$. The agent with the higher performance signal wins, and the loser obtains l. Given the continuous distribution of the individual error terms, for positive effort $e_i > 0$, the case of identical signal realizations occurs with zero probability and is, thus, henceforth neglected. Assuming that the loser cannot bribe the principal, the latter cannot manipulate total wage costs ex post by understating performance though signals are not verifiable. Denoting the prize spread by $\Delta := w - l$, agent i's gross payoff is given by:

$$\pi_i^T = \begin{cases} l & \text{if} \quad x_i < x_j \\ l + \Delta & \text{if} \quad x_i > x_j \end{cases}, \quad i \neq j \tag{4.3}$$

Accordingly, the utility of agent i upon winning is

$$U_i^w(e_i) = l + \Delta - c(e_i), \quad i = 1, 2, \tag{4.4}$$

whereas the corresponding utility if he loses is

$$U_i^l(e_i) = l - c(e_i) - \alpha\Delta, \quad i = 1, 2. \tag{4.5}$$

Hence, the loser not only receives a lower wage but also suffers from being outperformed. Since the probability of equal signal realizations is zero, inequitable payoff occurs with

$\alpha \max\{\pi_j - \pi_i, 0\} - \beta \max\{\pi_i - \pi_j, 0\}$, $\alpha > \beta > 0$. It is worth pointing out that incorporating empathy via the parameter $\beta > 0$ would not affect my qualitative results. Allowing for status preferences or pride as reflected by $\beta < 0$ would even strengthen the results. In contrast to my setup and that of Fehr and Schmidt (1999), Demougin and Fluet (2006) take effort costs into account when investigating inequity aversion; workers compare net payoffs. As homogeneous workers exert the same effort in equilibrium, an inclusion of effort cost does not affect my results, however.

certainty, and the tournament automatically leads to an unequal treatment of the agents ex post, even though agents are identical ex ante.

4.3.1 The Winning Probability

For notational convenience, designate the respective effort levels of agent i, j by e, a, and the signal realizations by x, y, respectively. Owing to the structure of the individual performance measures and given the agents' respective effort levels, the signals are independent random variables with support

$$S(e,a) := \{(x,y) \mid (0,0) \leq (x,y) \leq (e,a)\}. \tag{4.6}$$

The joint signal density obtains:

$$g(x,y|e,a) := \begin{cases} 0 & \text{if} \quad (x,y) \notin S(e,a) \\ \dfrac{1}{ae} & \text{if} \quad (x,y) \in S(e,a) \end{cases} \tag{4.7}$$

I denote $p(e|a)$ agent i's probability of winning the tournament, given that his co-worker exerts effort a. Thus,

$$p(e|a) = \Pr[x > y|e,a] = \Pr[e\varepsilon_i > a\varepsilon_j]. \tag{4.8}$$

Given the distribution of the error terms, that probability becomes:

$$p(e|a) = \begin{cases} \dfrac{1}{2}\dfrac{e}{a} & \text{if} \quad e \leq a \\ \\ 1 - \dfrac{1}{2}\dfrac{a}{e} & \text{if} \quad e > a \end{cases} \tag{4.9}$$

To see how the probabilities are derived from the density function consider Figure 4.1. The left graph of the figure represents the case $e \leq a$. Due to the tournament structure, player i wins only if signal realizations x, y to the right of the 45°-line occur. Given that the joint probability density function is a constant, the probability of winning multiplies $1/ae$ with the surface of the region where the agent wins; $e^2/2$. Altogether, we thus obtain:

$$\frac{1}{ae} \cdot \left(\frac{e^2}{2}\right) = \frac{1}{2}\frac{e}{a}. \tag{4.10}$$

The alternative case $e \geq a$ is illustrated by the right graph of the figure. The surface area to the right of the 45°-line is composed of $a^2/2$ and $(e-a)\,a$. Multiplying the

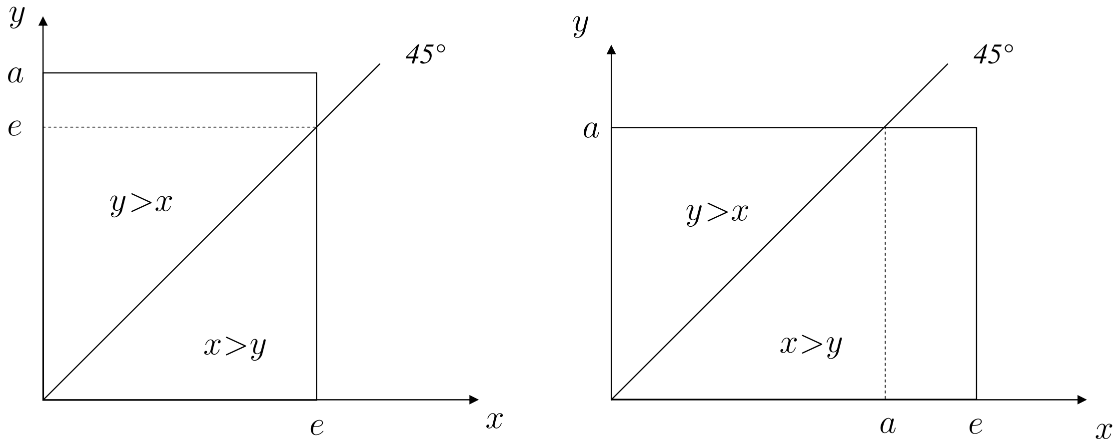

Figure 4.1: Possible realizations of the signals x, y for $e \leq a$ (left figure) and $e \geq a$ (right figure)

surface again with the density yields

$$\frac{1}{ae} \cdot \left(\frac{a^2}{2} + (e-a)\, a \right) = 1 - \frac{1}{2} \frac{a}{e}. \tag{4.11}$$

Altogether, $p\,(e|a)$ is increasing, concave and continuous in e. Moreover, $p\,(e|a)$ is continuously differentiable:

$$p'\,(e|a) := \frac{\partial p\,(e|a)}{\partial e} = \begin{cases} \frac{1}{2}\frac{1}{a} \text{ if } e \leq a \\ \\ \frac{1}{2}\frac{a}{e^2} \text{ if } e > a \end{cases}, \tag{4.12}$$

with $p'\,(e|a = e) = 1/\,(2a)$. Figure 4.2 below depicts both functions.

4.3.2 The Agent's Problem

Both agents simultaneously decide on their effort choice. I determine the equilibrium effort levels using the Nash-equilibrium concept. In the remainder, a denotes the amount of effort agent j exerts at the Nash-equilibrium. Agent i's optimization problem is thus given by

$$\max_e \quad EU_i\,(e, a; \alpha) = l + p\,(e|a)\,\Delta - c(e) - \alpha\,(1 - p\,(e|a))\,\Delta. \tag{4.I}$$

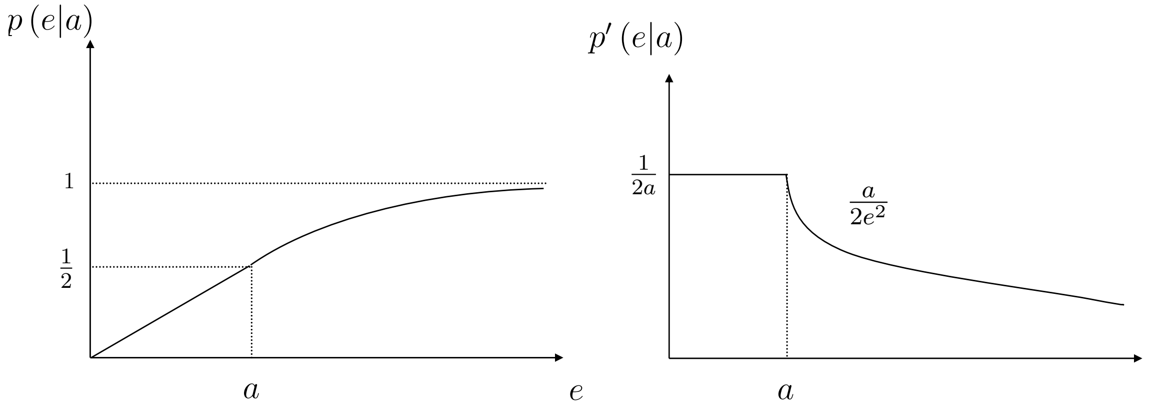

Figure 4.2: Winning-probability $p(e|a)$ and marginal winning probability $p'(e|a)$

The first-order condition yields

$$p'(e|a)(1+\alpha)\Delta = c'(e). \tag{4.13}$$

The Nash equilibrium of the agents' effort choices is symmetric and unique.[15] Thus, in order to elicit effort a, the principal offers the prize spread

$$\Delta(a;\alpha) = \frac{2ac'(a)}{(1+\alpha)}. \tag{ICT}$$

It follows that $\partial\Delta/\partial\alpha < 0$. Alternatively, for a given prize spread, the agents' effort incentives increase in the agents' propensity for envy. This observation is known as the *incentive effect of envy* (see e.g. Demougin and Fluet (2003) and Grund and Sliwka (2005)).[16]

4.3.3 The Principal's Wage Cost

In each period, the principal wishes to minimize her cost for implementing a given level of effort. Denote by $C^T(a)$ her average cost of implementing effort a. Solving the game by backward induction, the minimization problem is subject to the agents' incentive-compatibility and participation constraints. Her per-period objective is thus

[15]For a verification see the appendix. Moreover, it is worth pointing out that I use the difference in gross payoffs as a measure for inequity which is, however, only meaningful at the symmetric equilibrium where workers face identical cost of effort.

[16]The authors derive the effect for agents that are also compassionate. As in their setups envy dominates the latter emotion, altogether inequity aversion has a positive effort-strengthening effect.

given by

$$\begin{array}{ll} \min\limits_{l,\Delta} & 2C^T\left(a,l,\Delta\right) = 2l + \Delta \\ \text{s.t.} & \\ \text{(ICT)} & \Delta = \dfrac{2ac'(a)}{(1+\alpha)} \\ \text{(PCT)} & l + \frac{\Delta}{2} - c(a) - \alpha\frac{\Delta}{2} \geq \bar{u}, \end{array} \tag{4.II}$$

where (PCT) ensures the agents' participation in the contract. Note that, in expectation, each agent wins the tournament with probability 0.5. Since the loser prize l positively enters the principal's cost function, the participation constraint is binding in the optimal tournament contract, leading to zero rent for the agents. Using (ICT) and (PCT) in order to substitute l and Δ in the principal's objective function, we obtain the following result:

Lemma 4.1 *In a rank-order tournament, the principal's cost for implementing effort a is given by*

$$C^T\left(a;\alpha,\bar{u}\right) = c(a) + \frac{\alpha}{1+\alpha}ac'(a) + \bar{u}. \tag{4.14}$$

For a given effort level a, these wage costs are increasing in the parameter capturing envy. In the literature, these agency costs of inequity aversion are known as *inequity premium* (see e.g. Grund and Sliwka (2005)). They are represented by the second term of the principal's cost function (4.14). The preceding observations lead to the following conclusion.

Proposition 4.1 *In a rank-order tournament, the principal implements first-best effort a^* when agents are not envious. Once agents are envious, she implements second-best effort $a_T^{**} < a^*$. Per-period profits as well as implemented effort levels decrease in the agents' propensity for envy.*

Proof. The principal's profit maximization problem is given by

$$\max_a \quad \Pi^T\left(a;\alpha,\bar{u}\right) = v\left(a\right) - c(a) - \frac{\alpha}{1+\alpha}ac'(a) - \bar{u}. \tag{PI}$$

The first-order condition of the above problem yields:

$$v'\left(a_T^{**}\right) - \frac{\alpha}{1+\alpha}\left(c'(a_T^{**}) + a_T^{**}c''(a_T^{**})\right) = c'(a_T^{**}) \tag{4.15}$$

For $\alpha = 0$, the equation reduces to $v'\left(a^*\right) = c'(a^*)$ implying first-best effort levels. For $\alpha > 0$, by the implicit-function theorem, effort a_T^{**} is strictly decreasing in α. Using the envelope theorem, profits also decrease in α. ■

In comparing the incentive regimes in Section 4.5, I focus on stationary contracts. That is, I embed the above derived one-period problem into an infinitely repeated game.

4.4 The Bonus Contract

In the individual bonus contract, in each period the principal pays a fixed base wage A with certainty and promises to pay a bonus B whenever an agent's individual performance measure in the respective period meets or exceeds some ex ante fixed standard z. Keeping the foregoing notation, agent i's per-period gross monetary payoff is thus given by:

$$\pi_i^B = \begin{cases} A & \text{if} \quad x < z \\ A + B & \text{if} \quad x \geq z \end{cases} \tag{4.16}$$

Unlike in the tournament contract, agent i suffers from uneven payoffs only in the case that he does not obtain the bonus whereas his co-worker does. In particular, the additional loss due to inequity aversion amounts to αB.

4.4.1 The Benchmark Case: Verifiable Performance

In this section I initially analyze the benchmark case of verifiable performance signals. As credibility issues do not arise in this case, I only consider the single-period game.

4.4.1.1 The Agent's Problem

Given the contract and the underlying distribution function, the probability that agent i gets a bonus, $p(e|z) = \Pr[x \geq z|e]$, is given by

$$p(e|z) = \max\{0, 1 - \frac{z}{e}\}. \tag{4.17}$$

To see how equation (4.17) is obtained, consider Figure 4.3. For effort $e < z$ as depicted by e_0, the agent never obtains the bonus. In contrast, for effort $e > z$, e.g. e_1 in the figure, the agents receives the bonus with probability

$$(e - z)\frac{1}{e} = 1 - \frac{z}{e}. \tag{4.18}$$

For any $e \geq z$, the function $p(e|z)$ is increasing and strictly concave in effort.

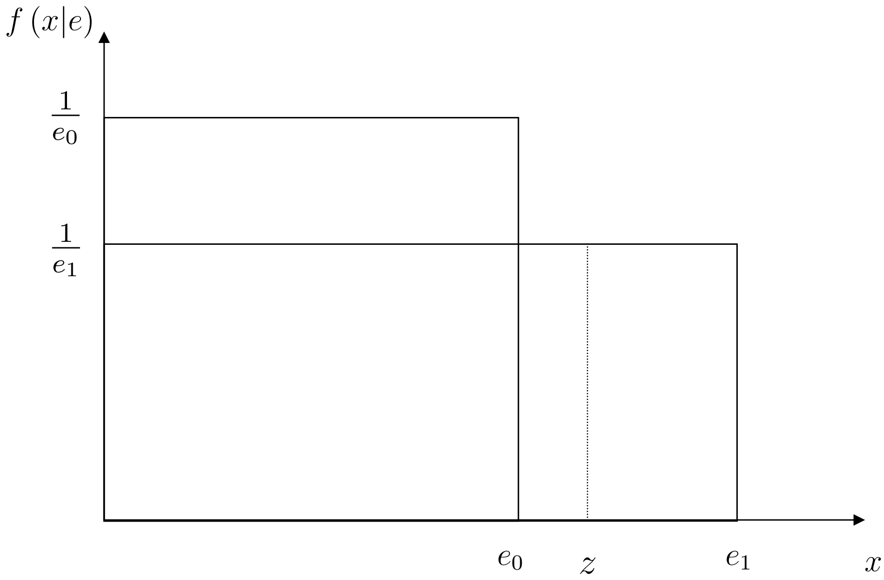

Figure 4.3: Signal densities $f(x|e)$ for two effort levels $e_0 < z < e_1$

Following the same conventions as in the foregoing section, agent i's expected utility is

$$EU_i(e, a, z; \alpha) = A + p(e|z) B - c(e) - \alpha (1 - p(e|z)) p(a|z) B, \tag{4.19}$$

where a denotes the other agent's effort at the Nash equilibrium. The expected disutility from being outperformed is captured by the last term in the above equation. Rewriting the agent's utility as

$$EU_i(e, a, z; \alpha) = A + p(e|z) \{1 + \alpha p(a|z)\} B - c(e) - \alpha p(a|z) B \tag{4.20}$$

we see that the agent will undertake a positive effort $e > 0$ only if

$$p(e|z) \{1 + \alpha p(a|z)\} B \geq c(e). \tag{IntC}$$

Otherwise, the worker is better off by choosing $e = 0$ (see Figure 4.4). In the remaining, the above requirement will be referred to as the interior-solution constraint.

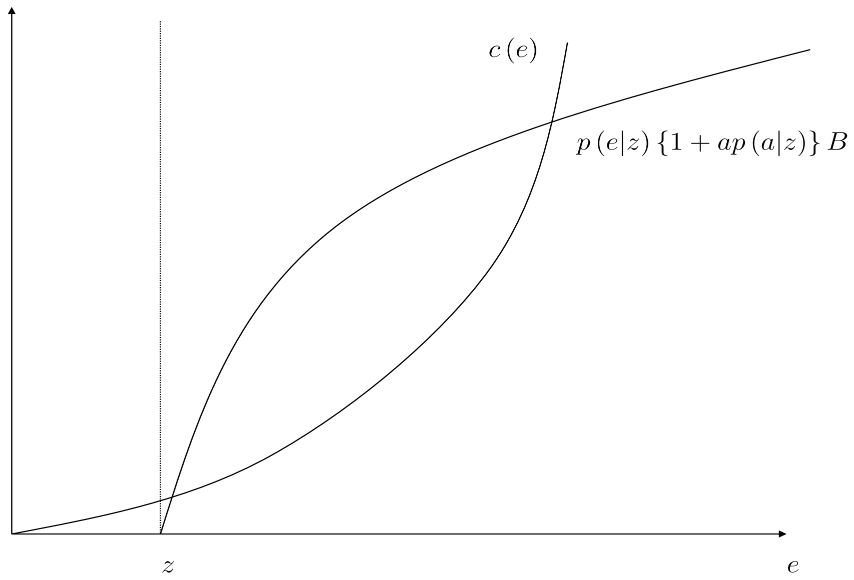

Figure 4.4: Interior-solution constraint of an agent's maximization problem

In the appendix 4.7, I verify that in case condition (IntC) is satisfied at the Nash-equilibrium, the equilibrium is unique and symmetric:[17]

$$a = \arg\max_{e} \quad A + p(e|z)\{1+\alpha p(a|z)\}B - c(e) - \alpha p(a|z)B \tag{4.21}$$

In the unique symmetric interior equilibrium, the first-order condition yields

$$p'(a|z)\{1+\alpha p(a|z)\}B - c'(a) = 0. \tag{ICB}$$

The condition again reveals the *incentive-strengthening effect of envy.* Intuitively, an increase in α has the same effect as raising the bonus.[18]

4.4.1.2 The Principal's Wage Cost

In this subsection, I analyze the cost minimization problem of the principal if she wants to implement effort a. From the foregoing, the principal solves:

[17]Eventhough there exist contracts that do not lead to an interior solution, these are not interesting since the principal will want the agents to undertake positive effort. Therefore I ignore these contracts in the following analysis of the agents' behavior.

[18]Again, the result is in line with the literature. Neilson and Stowe (2008) find a similar effect for piece-rate contracts. For the incentive effect under bonus contracts with binary signals see Demougin and Fluet (2006) and Kragl and Schmid (2008).

$$\begin{aligned}
&\min_{A,B,z} && C^B(a,A,B,z) = A + p(a|z)B \\
&\text{s.t.} && \\
&(\text{IntC}) && p(a|z)\{1+\alpha p(a|z)\}B \geq c(a), \\
&(\text{ICB}) && p'(a|z)\{1+\alpha p(a|z)\}B = c'(a), \\
&(\text{PCB}) && A + p(a|z)B - c(a) - \alpha(1-p(a|z))p(a|z)B \geq \bar{u}
\end{aligned} \tag{4.III}$$

where (IntC) guarantees that the agents are better off undertaking the desired effort level rather than no effort at all. Condition (ICB) is the standard incentive-compatibility constraint, equalizing marginal benefit and marginal cost of effort, and (PCB) ensures the agents' participation. Just as before (PCB) will be binding at the optimum, which allows to substitute A into the principal's objective function. Rewriting the problem yields:

$$\begin{aligned}
&\min_{B,z} && C^B(a,B,z;\alpha,\bar{u}) = c(a) + \alpha(1-p(a|z))p(a|z)B + \bar{u} \\
&\text{s.t.} && \\
&(\text{IntC}) && p(a|z)\{1+\alpha p(a|z)\}B \geq c(a), \\
&(\text{ICB}) && p'(a|z)\{1+\alpha p(a|z)\}B = c'(a)
\end{aligned} \tag{4.IV}$$

Lemma 4.2 *Assume that performance measures are verifiable and the principal wishes to implement effort a. Then solving problem (4.IV) for the optimal bonus contract B^*, z^* requires that the interior-solution constraint (IntC) is binding.*

Proof. Consider the principal's problem as given in (4.IV) and assume that condition (IntC) is not binding. Substituting B from condition (ICB) yields:

$$\min_z \; C^B(a,B,z;\alpha,\bar{u}) = c(a) + \frac{\alpha(1-p(a|z))p(a|z)c'(a)}{p'(a|z)\{1+\alpha p(a|z)\}} + \bar{u} \tag{PII}$$

The principal's objective becomes minimizing the inequity premium by the choice of z:

$$\min_z \; \frac{(1-p(a|z))p(a|z)}{p'(a|z)\{1+\alpha p(a|z)\}} \tag{PIII}$$

Plugging in the bonus probability as given in equation (4.17) and simplifying yields:

$$\min_z \; \frac{a-z}{1+\alpha\left(1-\frac{z}{a}\right)} \tag{PIV}$$

The first-order condition of the above problem is given by

$$0 = -\left(1 + \alpha\left(1 - \frac{z^+}{a}\right)\right) + \left(-\frac{\alpha}{a}\right)\left(a - z^+\right), \tag{4.22}$$

implying

$$z^+ = a. \tag{4.23}$$

With the second-order condition of problem (PIV) $2\alpha/a > 0$, we thus have a minimum. With $z^+ = a$, however $p\,(a|z^+) = 0$ while $c\,(a) > 0$ for any $a > 0$. This contradicts condition (IntC) as $0 \geq c\,(a)$ cannot be satisfied for any positive value of a. As a result, condition (IntC) must be binding. ■

To illustrate the intuition of the proof, consider Figure 4.5. It depicts the constraints of the principal's minimization problem as given in (4.IV) for a given level of effort.

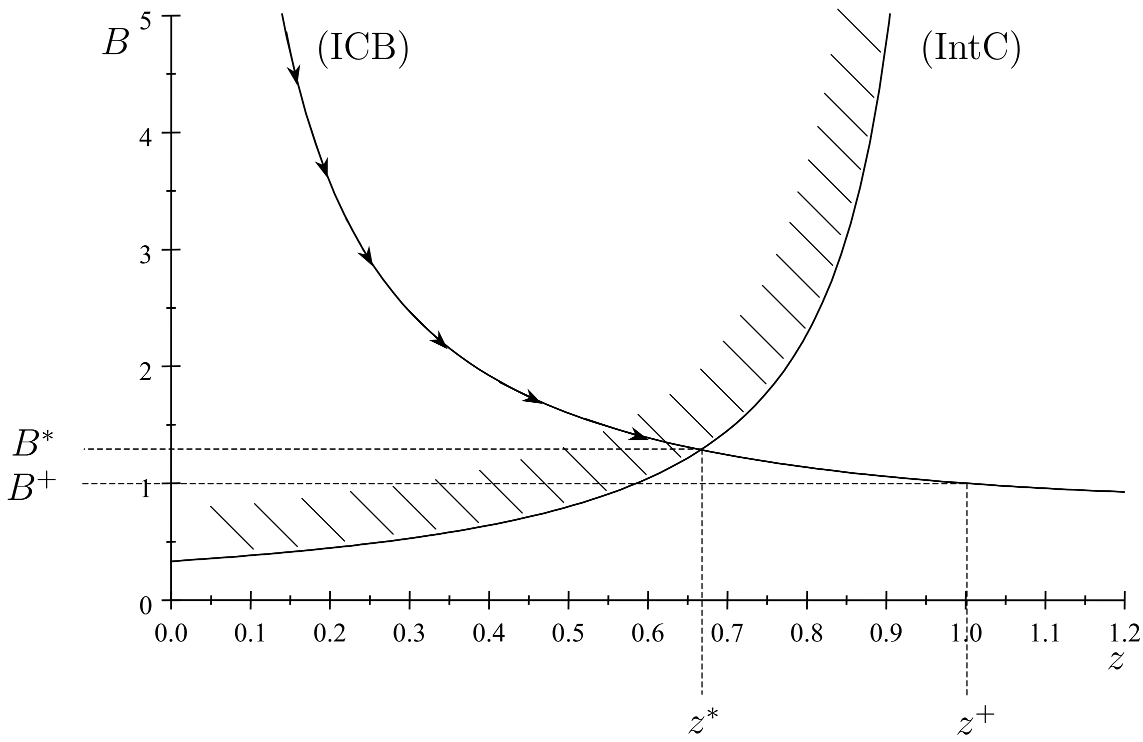

Figure 4.5: Conditions (ICB) and (IntC) with $c\,(a) = a^2/2, a = 1$, and $\alpha = 0.5$.

In the figure, observe that condition (ICB) implies that reducing the bonus B requires raising the performance standard z.[19] However, B, z must also satisfy the

[19]Note that a necessary condition for constraint (IntC) to be satisfied is $a > z$. The figure thus illustrates the constraints for these values of z.

interior-solution constraint. The shaded area depicts combinations B, z for which inequality (IntC) is satisfied.

Intuitively, if constraint (IntC) were not binding, the principal would want to choose z such that the inequity premium, i.e. the second term of her objective function in problem (4.IV), becomes zero. This implies $z = a$ as then $p(a|z) = 0$. However, zero bonus probability violates condition (IntC) as, with $a > 0$, the agents incur positive costs of effort. As can be seen in the figure, the solution of the relaxed problem denoted by B^{+}, z^{+} is thus located outside the shaded area. As a result, condition (IntC) must be binding.

From the foregoing follows that z^{*}, B^{*} are implicitly defined by the two constraints (ICB) and (IntC):

$$\begin{aligned} \frac{z^{*}}{a^{2}}\left\{1+\alpha\left(1-\frac{z^{*}}{a}\right)\right\} B^{*} &= c'(a) \\ \left(\frac{a-z^{*}}{a}\right)\left\{1+\alpha\left(1-\frac{z^{*}}{a}\right)\right\} B^{*} &= c(a) \end{aligned} \tag{4.24}$$

Figure 4.6 illustrates the solution to the above equation system. In particular, condition (ICB) requires the slope of the two curves to coincide while the (IntC)-constraint stipulates their intersection. As a result, the curves must be tangent. Solving for z^{*}, B^{*}, calculating $p(a|z^{*})$ and $p'(a|z^{*})$ and substituting the solutions in the principal's cost function yields the following result. For an explicit derivation see the appendix.

Lemma 4.3 *Assume that performance measures are verifiable and the principal wishes to implement effort a. Then the associated cost-minimizing bonus contract is given by*

$$B^{*}(a;\alpha) = \frac{\left(c(a)+c'(a)a\right)^{2}}{(1+\alpha)\,c(a)+c'(a)a}, \tag{4.25}$$

$$z^{*}(a) = \frac{a^{2}c'(a)}{c(a)+c'(a)a}. \tag{4.26}$$

Altogether, the principal's cost for implementing effort a is

$$C^{B}(a;\alpha,\bar{u}) = c(a) + \bar{u} + \frac{\alpha}{1+\alpha} ac'(a) \cdot \frac{c(a)}{c(a)+\frac{ac'(a)}{1+\alpha}}. \tag{4.27}$$

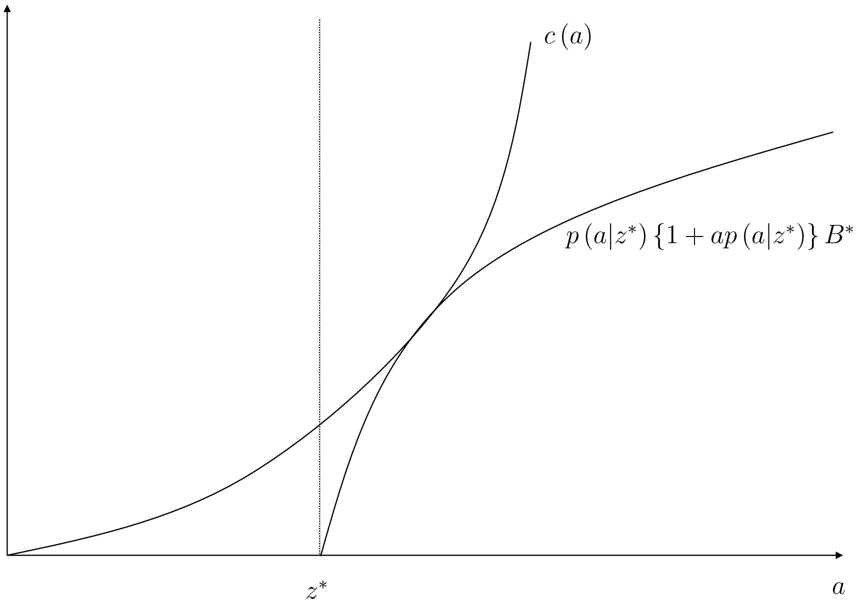

Figure 4.6: Solution of the 2×2-equation system for z^*, B^*

Note the incentive effect; $B^*(a;\alpha)$ is decreasing in α. However, for a given effort level a, overall wage costs are increasing in the parameter capturing envy.[20] With $\alpha > 0$, the principal incurs *inequity premium* costs because the agents must be compensated for the expected disutility from inequity.[21] The following proposition gives the main results of the foregoing analysis.

Proposition 4.2 *With verifiable performance measures and restricting the analysis to the individual bonus scheme, the principal implements first-best effort a^* when agents are not envious. Once agents are envious, she implements second-best effort $a_B^{**} < a^*$. Per-period profits decrease in the agents' propensity for envy.*

Proof. See the appendix 4.7. ■

4.4.1.3 Comparison with the Tournament

In the one-shot game with verifiable performance, the principal's wage cost for implementing a given effort level, differ in both types of contract only in the amount of the inequity premium. Naturally, this results from the characteristics of the two incentive

[20]For a proof see the appendix 4.7.

[21]The result is in line with the agency literature. See Bartling and von Siemens (2007), Kragl and Schmid (2008), and Neilson and Stowe (2008) for similar results in different setups.

regimes. Comparing the costs of implementing a given effort level as given by equations (4.14) and (4.27) directly yields the following result:

Proposition 4.3 *Assume that performance measures are verifiable and agents are envious. Then the wage cost for implementing an arbitrary effort level is strictly larger under the tournament contract than the wage cost under the individual bonus scheme.*

When $\alpha = 0$, wage costs are $C^B(a) = C^T(a) = c(a) + \bar{u}$, and the firm implements the first-best solution under either incentive regime. When $\alpha > 0$, however, the firm must compensate the agents for the expected disutilities implied by the respective pay structures. Intuitively, under the rank-order tournament, inequity occurs with certainty whereas in the bonus contract it arises only with some positive probability. As a result, the latter scheme dominates the former when performance measures are verifiable.

4.4.2 Non-verifiable Performance

The cost-minimizing tournament contract derived in Section 4.3 is not affected by the non-verifiability of the performance measures as the fixed sum of prizes is contracible. By contrast, in the individual bonus scheme, the principal may have an incentive to renege on the bonus ex post by understating the agent's performance. Thus, individual bonus contracts are feasible only if the principal is credible to keep her promise regarding the agreed terms of payments. In other words, the contracts must be self-enforcing. Mathematically, this requires introducing a credibility constraint on the side of the principal.

In order to do so, I embed the one-shot model analyzed above into an infinitely repeated game between the firm and an infinite sequence of workers.[22] Modeling trigger-strategy equilibria, I assume that, if the firm reneges on the bonus once, no agent believes the principal to adhere to the contract in any subsequent period of the game.[23] In particular, for simplicity, I assume that after a single contract breach the firm is not able to conclude another employment contract. Altogether, the principal's

[22]In particular, I focus on stationary contracts.

[23]In modeling reputation, I follow Baker et al. (1994). Implicitly, I assume the information on a principal's deviation from the contract to be rapidly transmitted to the labor market. Alternatively, as Baker et al. (1994) note, each period's agent learns the history of play before the period begins.

per-period objective thus becomes:

$$
\begin{array}{lll}
\max\limits_{a,B,z} & \Pi^B(a,B,z;\alpha,\bar{u}) = v(a) - C^B(a,B,z;\alpha,\bar{u}) & \\
\text{s.t.} & & \\
\text{(IntC)} & B \geq \dfrac{c(a)}{p(a|z)\{1+\alpha p(a|z)\}}, & \\
 & & (4.\text{V}) \\
\text{(ICB)} & B = \dfrac{c'(a)}{p'(a|z)\{1+\alpha p(a|z)\}}, & \\
 & & \\
\text{(CC)} & B \leq \dfrac{\Pi^B(a,B,z;\alpha,\bar{u})}{r}, &
\end{array}
$$

where $C^B(a,z,B;\alpha,\bar{u})$ is the firm's wage cost as defined in problem (4.IV). With r designating the firm's interest rate, condition (CC) guarantees credibility. The constraint requires it to be worthwhile to stick to the agreement; i.e. the gains from reneging must fall short of the discounted gains from continuing the contract.

In order to highlight the impact of the credibility constraint on the optimization problem, consider the size of the firm's interest rate. Given that r is sufficiently small, (CC) is not binding, and the principal implements the same contract as under verifiability, i.e. with $\alpha > 0$ she implements effort a_B^{**} and the associated bonus payment and performance standard; $B^*(a_B^{**};\alpha), z^*(a_B^{**})$. By contrast, for sufficiently large r, the foregoing contract is no more credible. In order to reestablish credibility, the principal must thus reduce the bonus payment. The following lemma implies that this requires lowering the implemented effort level.

Lemma 4.4 *Suppose that performance measures are non-verifiable. Assuming that the optimal bonus contract solving problem (4.V) implements credible effort* a^c*, the principal uses the bonus* $B^*(a^c;\alpha)$ *and the standard* $z^*(a^c)$*, where* B^*, z^* *are defined by equations (4.25) and (4.26).*

Proof. To verify the claim, all we need to show is that condition (IntC) is binding in problem (4.V) for an arbitrary effort level. To prove this, I again use Figure 4.5 from Section 4.4.1, which depicts the constraints (ICB) and (IntC) as given in problem (4.V) for a fixed effort level. First, consider the case that r is such that condition (CC) is not binding for the bonus that implements the desired effort level. Problem (4.V) then resembles the problem under verifiability, and by Lemma 4.2 condition (IntC) is binding. Secondly, consider the case that condition (CC) is binding. Denote by $B_{\max}$

the bonus payment that makes (CC) binding for the desired effort level and a given interest rate r. Initially, suppose that $B_{\max} \geq B^*$ in Figure 4.5. Then the desired effort level can always be implemented by choosing B^*, z^* (or any combination B, z on the (ICB)-curve for which $B^* \leq B \leq B_{\max}$). By contrast, if $B_{\max} < B^*$, the desired effort level is not implementable by any choice of B, z. Consequently, the principal must assure that $B_{\max} = B^*$ by adapting the induced effort level. In the appendix, I verify that the system of the two binding constraints (ICB) and (IntC) defining B^*, z^* implies that $\partial B^*/\partial a, \partial z^*/\partial a > 0$. To reestablish implementability, the principal must thus reduce effort. For the reduced effort level, Figure 4.5 then looks alike, and the logic from above applies. Consequently, without loss of generality, the optimal credibility-constrained bonus contract B^*, z^* is given by the equation system (4.24), as depicted in Figure 4.5 by the intersection of the conditions (ICB) and (IntC). ■

Given the above result, the credibility constraint can now be written as

$$rB^*\left(a;\alpha\right) \leq \Pi^B\left(a;\alpha,\bar{u}\right). \tag{CC*}$$

As discussed above, for sufficiently small r, the condition (CC*) is not binding, and the firm implements effort a_B^{**}. As r increases, at a particular point, $B^*\left(a_B^{**};\alpha\right)$ is no longer credible, and the firm needs to lower the induced effort level in order to reduce the bonus payment. In particular, the largest credible effort level is decreasing in r. By concavity of the profit function, profits must thus also decrease. Altogether, we obtain the following result.

Proposition 4.4 *Assume that performance measures are non-verifiable. Then, under the individual bonus scheme, there is an interest rate $\hat{r}$ such that*

$$\hat{r}B^*\left(a_B^{**};\alpha\right) = \Pi^B\left(a_B^{**};\alpha\right). \tag{4.28}$$

(i) For any interest rate $r \leq \hat{r}$, the principal implements effort a_B^{**} and realizes profits $\Pi^B\left(a_B^{**};\alpha\right)$ *as under verifiability.*
(ii) For any interest rate $r > \hat{r}$, she implements an effort level $a^c\left(r\right) < a_B^{**}$ that just satisfies condition (CC) for the given interest rate. Profits are strictly smaller than under verifiability;* $\Pi^B\left(a^c\left(r\right);\alpha\right) < \Pi^B\left(a_B^{**};\alpha\right)$.

4.5 Comparison of the Incentive Schemes

In section 4.4.1 I verified that the principal is better off with an individual bonus scheme when performance measures are verifiable and agents are envious. In section 4.4.2 we saw that the advantage of the bonus scheme is, however, weakened when performance measures are non-verifiable and the firm runs into credibility problems. This is due to the fact that the choice of effort levels is then restricted by the credibility constraint.

In the present section, I first compare the two incentive schemes for non-verifiable performance and a given positive degree of envy. Moreover, I investigate the impact of a variation in the agents' propensity for envy on the relative profitability of the two regimes. In order to keep the analysis tractable, in the remaining, I consider a simple example with $v(a) = a, c(a) = 0.5a^2$, and $\bar{u} = 0$.[24] The results are generalizable, but using the example, however, greatly simplifies the analysis.

4.5.1 Profits

In each period, the principal wishes to maximize expected per-agent profits. From the foregoing, for the given example, her objective under the rank-order tournament is given by

$$\max_a \qquad \Pi^T(a;\alpha) = a - \left(\frac{1}{2} + \tfrac{\alpha}{1+\alpha}\right)a^2, \tag{4.VI}$$

whereas under the bonus scheme her problem becomes

$$\begin{array}{lc} \max_{a,B^*} & \Pi^B(a;\alpha) = a - \left(\dfrac{1}{2} + \dfrac{\alpha}{3+\alpha}\right)a^2 \\ \text{s.t.} & \\ (\text{CC}^*) & rB^*(a;\alpha) \leq \Pi^B(a;\alpha), \\ (\text{ICB}) & B^*(a;\alpha) = \dfrac{9}{2}\dfrac{a^2}{3+\alpha}. \end{array} \tag{4.VII}$$

To shed light on the interest rate's impact on the profitability of the individual bonus contract and allow for a comparison with the tournament, I illustrate the credibility constraint as given in (CC*) in Figure 4.7. In the figure, I plot the profit functions under both incentive regimes for a given value of envy. Moreover, the convex curves depict $rB^*(a)$ for different interest rates, $r^S > r > \hat{r}$.

[24] For traceability, I give the solutions of the model variables derived in the preceding sections for the example in the appendix. 4.7

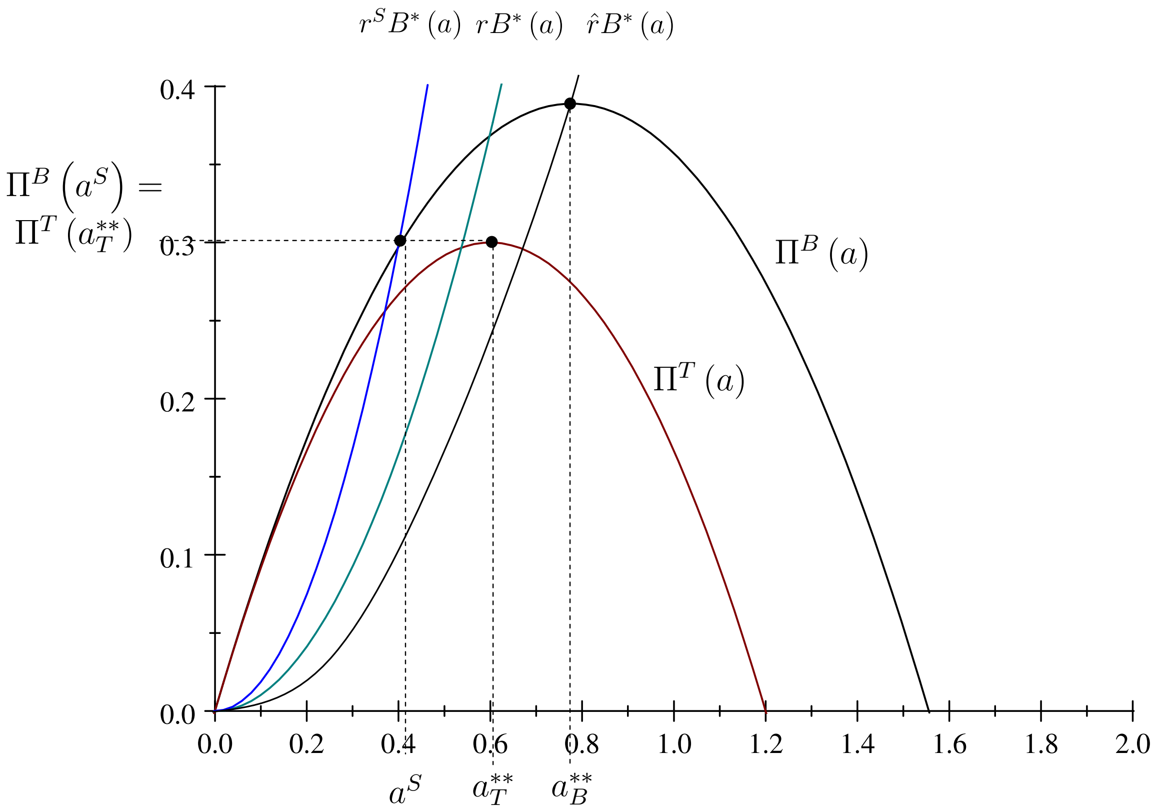

Figure 4.7: Profit functions in the bonus contract and the tournament, and the credibility constraint with $\alpha = 0.5$.

In the tournament contract, the principal needs not account for a credibility constraint such that she implements a_T^{**} and realizes profits $\Pi^T \left(a_T^{**}\right)$ for any interest rate r. Under the bonus contract, as long as $r \leq \hat{r}$, profits are also not affected by the interest rate; the firm implements a_B^{**} and realizes profit $\Pi^B \left(a_B^{**}\right) > \Pi^T \left(a_T^{**}\right)$. However, once $r > \hat{r}$, the size of r has a negative impact on the firm's profit under the bonus contract. In the figure, for a given value of r, the realized profit and the corresponding credible effort level $a^c (r)$ are determined by the intersection of the two curves $\Pi^B (a)$ and $rB^* (a)$. Observe that with increasing r, the firm lowers effort below a_B^{**}, thereby realizing reduced profit $\Pi^B (a^c (r)) < \Pi^B \left(a_B^{**}\right)$.

Importantly, the figure shows that there is a critical interest rate r^s for which effort $a^c \left(r^S\right) =: a^S$ is implemented, and profit $\Pi^B \left(a^S\right)$ under the bonus scheme corresponds to profit $\Pi^T \left(a_T^{**}\right)$ under the tournament.[25] Note that it is optimal for the principal

[25]In the present analysis, I assume $\bar{u} = 0$. Note that with $\bar{u} > 0$, the switching point r^S, a^S may become the point where $rB^* (a)$ is tangent to $\Pi^B (a)$. Then for any $r > r^S$, individual bonus contracts are no longer feasible. Note that with $\bar{u} > 0$, it may be the case that $\Pi^B \left(a^S\right) > \Pi^T \left(a_T^{**}\right)$. In that

to switch to the tournament contract for any interest rate $r > r^S$. The preceding observations directly yield the following result.

Proposition 4.5 *Assume that performance measures are non-verifiable and agents are envious. Then there is an interest rate r^S such that*

$$\Pi^B \left(a^c \left(r^S\right); \alpha\right) = \Pi^T \left(a_T^{**}; \alpha\right). \tag{4.29}$$

(i) For any interest rate $r < r^S$, the firm is better off under an individual bonus contract.
(ii) For any interest rate $r > r^S$, the firm is better off under the rank-order tournament.

Intuitively, profit in the tournament suffers from large inequity premium costs as inequitable payoff distributions cannot be avoided. The individual bonus scheme outperforms the tournament in that respect since expected payoff distributions are more even. As a result, the latter incentive regime is more profitable as long as credibility problems are not too severe. For sufficiently large interest rates, however, credibly implementable effort levels in the bonus contract lead to a profit smaller than that under the tournament such that the latter contract becomes superior. Interestingly, at the switching point, implemented effort increases from a^S to a_T^{**}. Thus, under the tournament, agents must work harder albeit the firm receives the same profit as under the bonus contract. Intuitively, the firm must pay the agents a larger wage in order to compensate them for the increased expected payoff inequity under the tournament. The principal is compensated for these higher wage payments by an increased output.

4.5.2 The Impact of Envy on the Relative Profitability

In the foregoing subsection, I analyzed the relative profitability of the two incentive schemes for a given degree of envy. By equation (4.29), the parameter capturing envy, however, endogenously determines the interest rate r^S for which it is optimal for the firm to switch from the individual bonus contract to the tournament. In order to explicitly investigate the issue, we solve the principal's optimization programs as given in problems (4.VI) and (4.VII). This yields the respective optimal effort levels under the two incentive schemes for given values of α and r. Moreover, solving for the switching point $\left(r^S, a^S\right)$ as defined by equation (4.29) then implicitly yields $r^S(\alpha)$. This allows to directly analyze the impact of envy on that critical interest rate. As a first step, the following lemma gives the solutions to the respective optimization problems.

case, the interest rate r^S would depend on $\bar{u}$. For an analysis of the impact of envy on the interest rate for which bonus contracts become infeasible see Kragl and Schmid (2008).

Lemma 4.5 *Assume that performance is not verifiable and agents are envious. Moreover, suppose* $v(a) = a, c(a) = 0.5a^2$*, and* $\bar{u} = 0$*.*
(i) In the rank-order tournament, the principal implements an effort level

$$a_T^{**}(\alpha) = \left(1 + \frac{2\alpha}{1+\alpha}\right)^{-1}. \tag{4.30}$$

(ii) In the individual bonus scheme, for any $r \leq \hat{r} = \left(\frac{1}{3}\alpha + \frac{1}{3}\right)$*, the credibility constraint is not binding, and the principal implements an effort level*

$$a_B^{**}(\alpha) = \left(1 + \frac{2\alpha}{3+\alpha}\right)^{-1}. \tag{4.31}$$

(iii) In the individual bonus scheme, for any $r > \hat{r} = \left(\frac{1}{3}\alpha + \frac{1}{3}\right)$*, the credibility constraint is binding, and the principal implements an effort level*

$$a^c(\alpha, r) = \left(1 + \frac{0.5\alpha + 4.5r - 1.5}{3+\alpha}\right)^{-1}. \tag{4.32}$$

Proof. See the appendix 4.7. ■

Next, plugging in the effort levels $a_T^{**}(\alpha)$ and $a^c(\alpha, r)$ in equation (4.29), implicitly yields $r^S(\alpha)$. In the appendix, I derive that implicit function and, moreover, verify that $\partial r^S / \partial \alpha > 0$. Thus, envy has a positive impact on the critical interest rate for which the firm switches from the bonus contract to the tournament. The following proposition summarizes this result.

Proposition 4.6 *Assume performance is not verifiable and agents are envious. Moreover, suppose* $v(a) = a, c(a) = 0.5a^2$*, and* $\bar{u} = 0$*. Then the more envious the agents are, the larger is the critical interest rate* $r^S(\alpha)$ *and, consequently, also the range of interest rates for which the individual bonus scheme dominates the rank-order tournament.*

Hence, the degree of envy impacts the relative profitability of the two considered incentive contracts in favor of the bonus scheme. Intuitively, an increasing propensity for envy affects both incentive regimes to a different extent. Profits in the tournament clearly decrease. In the individual bonus scheme, however, envy has an ambiguous impact on the credibility constraint and, thus, on profits in the optimum. In section 4.4.1, we derived two particular implications of envy. Specifically, the incentive effect of envy allows for lowering the bonus for a given effort level. As a result, the left-hand side of the credibility constraint is decreasing in the degree of envy which favors credibility. By contrast, due to the inequity premium effect the right-hand side of the constraint is also decreasing in envy, thereby making credibility more difficult. Thus, from the outset, it is not clear, the relative profitability of which contract is favored by an increasing propensity for envy. However, my analysis shows that envy clearly benefits the relative performance of the individual bonus contract.

4.6 Concluding Remarks

In a moral-hazard environment, I compare the profitabilities of relative and individual performance pay when a firm employs two envious workers whose respective performances are not verifiable. My findings underline that social preferences play a non-negligible role for the design of incentive schemes.[26] In particular, when agents do not care about relative payoffs, a rank-order tournament clearly outperforms individual bonus contracts as the former solves the non-verifiability problem altogether. The present analysis shows that this result is reversed for a considerable range of interest rates once agents are envious.

The paper highlights an interesting trade-off. With envious agents, the tournament becomes more costly than the bonus contract in terms of inequity premium costs. Thus, for a range of sufficiently small interest rates, the latter incentive contract dominates the former. For sufficiently large interest rates, however, credibility requirements restrict the set of implementable effort levels under the bonus scheme thereby reducing profits. Hence, the firm switches to the tournament contract at some level of interest rate. Moreover, my analysis suggests that the more envious the agents are the more likely is an individual bonus scheme to be superior. For a simple example, I show that the range of interest rates for which the bonus contract dominates the tournament is increasing in the agents' propensity for envy. Thus, fairness concerns render the individual pay scheme relatively more profitable even though it must be self-enforcing.

It is worth briefly discussing some assumptions of my model. First, regarding the shape of the agents' inequity aversion I have solely focused on envy. However, the trade-off concerning the relative performance of the two incentive regimes presented in my paper still carries over to the case that agents are also compassionate as proposed by Fehr and Schmidt (1999). Specifically, inequity premium costs increase under both

[26] Not surprisingly, empirical evidence shows that social preferences differ between cultures. For instance, Alesina et al. (2004) and Corneo (2001) find Europeans to exhibit a higher propensity for inequity aversion in comparison to U.S.-Americans.

contracts even further since the agents must not only be compensated for the expected inequity from being outperformed but also for that from being ahead. This makes the tournament even less profitable and impedes the firm's credibility under the bonus contract. In addition, empathy counteracts the incentive effect (see e.g. Grund and Sliwka (2005)). However, as has been found by e.g. Loewenstein et al. (1989), agents dislike being outperformed to a larger extent than they resent being ahead. Formalizing the notion of compassion by the parameter β, Fehr and Schmidt (1999) therefore assume $\alpha > \beta$. As a result, inequity aversion still has an, albeit smaller, overall incentive-strengthening effect. Altogether, credibility in the bonus scheme thus becomes more difficult to achieve when empathy is additionally introduced which makes that contract relatively less profitable. However, the firm still prefers the bonus scheme for small interest rates but switches to the tournament for sufficiently large ones.

Secondly, it is worth pointing out that in modeling reputation I have made a restrictive assumption. Specifically, I have assumed that the firm cannot enter another employment contract after once reneging on the individual bonus contract. It is, however, plausible to assume that the firm can still contract with the agents using a rank-order tournament. Such an assumption indeed affects the firm's credibility constraint under the bonus contract. Particularly, her loss from reneging on the agreement becomes smaller. However, my results reestablish for this case. Specifically, as long as the credibility constraint is not binding, the individual bonus scheme still dominates the tournament as it entails smaller inequity premium costs. The interest rate for which the constraint becomes binding will, however, be smaller as a positive fallback profit decreases the right-hand side of the credibility constraint. Consequently, profits under the bonus contract will start to decrease for smaller interest rates compared to the case analyzed in the present paper. Yet the firm will switch to the tournament once the interest rate is such that profits under the bonus contract undercut those in the tournament. Indeed, that critical interest rate must then be smaller as well.

4.7 Appendix

Proofs for Section 4.3

Proof of symmetry and uniqueness of the Nash-equilibrium. The agents' respective first-order conditions are given by

$$p'(e|a)(1+\alpha)\Delta = c'(e), \tag{4.33}$$
$$p'(a|e)(1+\alpha)\Delta = c'(a). \tag{4.34}$$

Combining both equations implies

$$\frac{p'(e|a)}{p'(a|e)} = \frac{c'(e)}{c'(a)}. \tag{4.35}$$

Consider the case $e \leq a$. By equation (4.12), the marginal probabilities are then given by

$$p'(e|a) = \frac{1}{2}\frac{1}{a}, \tag{4.36}$$
$$p'(a|e) = \frac{1}{2}\frac{e}{a^2}. \tag{4.37}$$

Equation (4.35) thus becomes

$$\frac{a}{e} = \frac{c'(e)}{c'(a)}. \tag{4.38}$$

Reformulation yields

$$c'(a)a = c'(e)e. \tag{4.39}$$

Note that $c'(e)\,e$ is a monotonically increasing function of effort:

$$\frac{\partial\left(c'(e)\,e\right)}{\partial e} = c''(e)\,e + c'(e) > 0$$

Thus, equation (4.39) is satisfied if and only if $e = a$. Hence, the Nash-equilibrium is symmetric. It is also unique as

$$a = \arg\max_{e} EU_i(e,a). \tag{4.40}$$

The proof for the case $e \geq a$, is conducted equivalently by simply reversing the effort variables e, a. ∎

Proofs for Section 4.4.1

Proof of symmetry and uniqueness of the Nash-equilibrium. Assume that condition (IntC) is satisfied. Both agents maximize their expected utility:

$$EU_i\left(e,a,z;\alpha\right)=A+p\left(e|z\right)\{1+\alpha p\left(a|z\right)\}B-c(e)-\alpha p\left(a|z\right)B$$

The respective first-order conditions are given by

$$p'\left(e|z\right)\{1+\alpha p\left(a|z\right)\}B-c'(e)=0, \tag{4.41}$$

$$p'\left(a|z\right)\{1+\alpha p\left(e|z\right)\}B-c'(a)=0. \tag{4.42}$$

Combining both equations implies

$$\frac{c'\left(e\right)}{p'\left(e|z\right)\left(1+\alpha p\left(a|z\right)\right)}=\frac{c'\left(a\right)}{p'\left(a|z\right)\left(1+\alpha p\left(e|z\right)\right)} \tag{4.43}$$

$$\Leftrightarrow\frac{c'\left(e\right)\left(1+\alpha p\left(e|z\right)\right)}{p'\left(e|z\right)}=\frac{c'\left(a\right)\left(1+\alpha p\left(a|z\right)\right)}{p'\left(a|z\right)}. \tag{4.44}$$

Both sides of equation (4.44) represent a function of an agent's effort level:

$$\frac{c'\left(\cdot\right)\left(1+\alpha p\left(\cdot\right)\right)}{p'\left(\cdot\right)} \tag{4.45}$$

The above function is monotonically increasing in effort. To see this, consider the derivative of (4.45) with respect to effort:

$$\frac{(1+\alpha p\left(\cdot\right))p'\left(\cdot\right)c''\left(\cdot\right)+\alpha p'\left(\cdot\right)^2c'\left(\cdot\right)-p''\left(\cdot\right)c'\left(\cdot\right)\left(1+\alpha p\left(\cdot\right)\right)}{p'\left(\cdot\right)^2}. \tag{4.46}$$

Note that for an interior solution to exist it must hold that $a>z$. As then $\alpha,p\left(a|z\right),$ $p'\left(a|z\right),c''\left(a\right),c'\left(a\right)>0$, and $p''\left(a|z\right)<0$, expression (4.46) is strictly positive. Thus, equation (4.44) is satisfied if and only if $e=a$. Hence, the equilibrium is symmetric. Moreover, as

$$a=\arg\max_{e}EU_i\left(e,a,z;\alpha\right) \tag{4.47}$$

the equilibrium is also unique. ■

Proof of Lemma 4.3. The equation system (4.24) implies

$$\frac{c\,(a)\,a}{(a-z^*)} = \frac{c'(a)a^2}{z^*}. \tag{4.48}$$

Solving for z^* yields

$$z^*\,(a) = \frac{a^2 c'(a)}{c\,(a) + c'(a)a}. \tag{4.49}$$

By equation (4.17), the probability of receiving a bonus is then positive:

$$p\,(a|z^*) = 1 - \frac{z^*\,(a)}{a} \tag{4.50}$$

$$\Rightarrow p\,(a) = \frac{c\,(a)}{c\,(a) + c'(a)a} \tag{4.51}$$

The marginal probability of receiving a bonus becomes:

$$p'\,(a|z^*) = \frac{z^*\,(a)}{a^2} \tag{4.52}$$

$$\Rightarrow p'\,(a) = \frac{c'(a)}{c\,(a) + c'(a)a} \tag{4.53}$$

Substituting the above results into condition (ICB) yields the incentive-compatible bonus as given in (4.25):

$$B\,(a, z^*; \alpha) = \frac{c'(a)}{p'\,(a|z^*)\,(1 + \alpha p\,(a|z^*))} \tag{4.54}$$

$$\Rightarrow B^*\,(a) = \frac{(c\,(a) + c'(a)a)^2}{(1+\alpha)\,c\,(a) + c'(a)a} \tag{4.55}$$

From the foregoing, the principal's per-worker cost function is

$$C^B\,(a, B^*, z^*; \alpha, \bar{u}) = c\,(a) + \alpha\,(1 - p\,(a|z^*))\,p\,(a|z^*)\,B^* + \bar{u}. \tag{4.56}$$

Substituting $B\,(a, z^*; \alpha)$ yields

$$C^B\,(a, z^*; \alpha, \bar{u}) = c\,(a) + \alpha c'\,(a) \cdot \frac{(1 - p\,(a|z^*))\,p\,(a|z^*)}{p'\,(a|z^*)\,\{1 + \alpha p\,(a|z^*)\}} + \bar{u}. \tag{4.57}$$

Plugging in $p\left(a|z^*\right)$ and $p'\left(a|z^*\right)$, the per-worker costs for implementing effort a become

$$C^B\left(a;\alpha,\bar{u}\right)=c\left(a\right)+\bar{u}+\alpha\frac{ac\left(a\right)c'\left(a\right)}{\left(1+\alpha\right)c\left(a\right)+ac'(a)}. \tag{4.58}$$

Rearranging terms yields the expression given in equation (4.27). ■

Proof that wage costs are increasing in α. Differentiating equation (4.58) wrt α yields a positive expression:

$$\frac{\partial C^B\left(a;\alpha,\bar{u}\right)}{\partial\alpha}=ac\left(a\right)c'\left(a\right)\cdot\frac{c\left(a\right)+ac'\left(a\right)}{\left(\left(1+\alpha\right)c\left(a\right)+ac'\left(a\right)\right)^2} \tag{4.59}$$

■

Proof of Proposition 4.2. The principal's profit maximization problem is given by

$$\max_a \quad \Pi^B\left(a;\alpha,\bar{u}\right)=v\left(a\right)-c\left(a\right)-\bar{u}-\frac{\alpha}{1+\alpha}\cdot\frac{ac'\left(a\right)c\left(a\right)}{c\left(a\right)+\frac{ac'(a)}{1+\alpha}}. \tag{AI}$$

For notational convenience, denote $\frac{ac'\left(a\right)c\left(a\right)}{c\left(a\right)+\frac{ac'(a)}{1+\alpha}}=X\left(a\right)$. Then the first-order condition of the above problem yields:

$$v'\left(a_B^{**}\right)=c'\left(a_B^{**}\right)+\frac{\alpha}{1+\alpha}\cdot X'\left(a_B^{**}\right) \tag{4.60}$$

For $\alpha=0$, the equation reduces to $v'\left(a_B^{**}\right)=c'(a_B^{**})$ implying first-best effort levels $a_B^{**}=a^*$. For $\alpha>0$, the last term of the above equation is given by

$$X'\left(a_B^{**}\right)=\frac{\left[c'c+ac''c+ac'c'\right]\left[c+\frac{ac'}{1+\alpha}\right]-ac'c\left[c'+\frac{c'+ac''}{1+\alpha}\right]}{\left[c+\frac{ac')}{1+\alpha}\right]^2}, \tag{4.61}$$

where $c'=c'\left(a_B^{**}\right)$ and $c=c\left(a_B^{**}\right)$. Reformulation verifies that the term is strictly positive:

$$X'\left(a_B^{**}\right)=\frac{c'cc+ac''cc+ac'c'\frac{ac'}{1+\alpha}}{\left[c+\frac{ac'}{1+\alpha}\right]^2}>0 \tag{4.62}$$

Due to the concavity of the value function $v\left(a\right)$ and strict convexity of the cost function $c\left(a\right)$, equation (4.60) is satisfied only for values $a_B^{**}<a^*$. Moreover, by inequality (4.59) wage costs and thus $\frac{\alpha}{1+\alpha}\cdot X\left(a_B^{**}\right)$ strictly increase in α. Using the envelope theorem, profits must consequently decrease in that parameter. ■

Proofs for Section 4.4.2

Proof of Lemma 4.4 ctd. As derived in the proof of Lemma 4.3 above, the equation system (4.24) consisting of the two binding constraints (IntC) and (ICB) implies

$$z^*(a) = \frac{a^2 c'(a)}{c(a) + c'(a)a}. \tag{4.63}$$

Differentiating this expression with respect to effort yields a positive expression:

$$\frac{\partial z^*(a)}{\partial a} = ac(a) \cdot \frac{ac''(a) + 2c'(a)}{(c(a) + ac'(a))^2} \tag{4.64}$$

Moreover, given that condition (IntC) is binding, the constraint (ICB) can be written as:

$$\frac{z^*}{a^2}\{1 + \alpha\left(1 - \frac{z^*}{a}\right)\}B^* - c'(a) = 0 \tag{4.65}$$

Substituting $z^*(a)$ implicitly yields the bonus B^*, implied by system (4.24):

$$\frac{c'(a)}{c(a) + c'(a)a}\left\{1 + \alpha\left(\frac{c(a)}{c(a) + c'(a)a}\right)\right\}B^* - c'(a) = 0 \tag{4.66}$$

Applying the implicit-function theorem yields the effect of a variation in effort a on the incentive-compatible bonus B^*:

$$\frac{\partial B^*}{\partial a} = -\frac{soc}{\frac{c'(a)}{c(a)+c'(a)a}\left\{1 + \alpha\left(\frac{c(a)}{c(a)+c'(a)a}\right)\right\}}, \tag{4.67}$$

where *soc* denotes the second-order condition of the agent's maximization problem. Assuming concavity of the utility function, that term must be negative. Given that the denominator is positive, also expression (4.67) is positive. Altogether, the effect of an increase in the induced effort level a on the bonus $B^*(a;\alpha)$ as well as on the performance standard $z^*(a)$ is thus positive. ■

Solutions to the model for $c(a) = \frac{1}{2}a^2$

Plugging in $c(a) = 0.5a^2$ in the solutions to the model variables given in the text yields the following values:

Solutions to the rank-order tournament.

$$\Delta(a) = \frac{2a^2}{(1+\alpha)} \tag{4.68}$$

$$C^T(a) = \left(\frac{1}{2} + \frac{\alpha}{1+\alpha}\right) a^2 + \bar{u} \tag{4.69}$$

Solutions to the individual bonus contract.

$$z^*(a) = \frac{2a}{3} \tag{4.70}$$

$$p(a) = \frac{1}{3} \tag{4.71}$$

$$p'(a) = \frac{2}{3a} \tag{4.72}$$

$$B^*(a) = \frac{9}{2}\frac{a^2}{3+\alpha} \tag{4.73}$$

$$C^B(a) = \left(\frac{1}{2} + \frac{\alpha}{3+\alpha}\right) a^2 + \bar{u} \tag{4.74}$$

Proofs for Section 4.5

Proof of Lemma 4.5. (i) With $\bar{u} = 0$, in the tournament, the principal's objective is:

$$\max_a \quad \Pi^T(a;\alpha) = a - \left(\frac{1}{2} + \frac{\alpha}{1+\alpha}\right) a^2 \tag{AII}$$

The first-order condition is given by

$$0 = 1 - 2\left(\frac{1}{2} + \frac{\alpha}{1+\alpha}\right) a_T^{**}. \tag{4.75}$$

Reformulation directly yields $a_T^{**}(\alpha)$ as given in equation (4.30).
(ii) In the bonus scheme, given that (CC*) is not binding, the principal's objective is:

$$\max_a \quad \Pi^B(a;\alpha) = a - \left(\frac{1}{2} + \frac{\alpha}{3+\alpha}\right) a^2 \tag{AIII}$$

The first-order condition is given by:

$$0 = 1 - 2\left(\frac{1}{2} + \frac{\alpha}{3+\alpha}\right) a_B^{**}. \tag{4.76}$$

Reformulation directly yields the profit-maximizing effort level $a_B^{**}(\alpha)$ as given in equation (4.31). By Proposition 4, that effort level can be implemented only for values of $r \leq \hat{r}$. The interest rate $\hat{r}$ is implicitly defined in equation (4.28):

$$\hat{r} B\left(a_B^{**}; \alpha\right) = \Pi^B\left(a_B^{**}; \alpha\right) \tag{4.77}$$

Calculating $B\left(a_B^{**}; \alpha\right)$ and $\Pi^B\left(a_B^{**}; \alpha\right)$ by plugging in $a = a_B^{**}$ in the functions given in problem (4.VII), and then solving equation (4.77) for $\hat{r}$ yields

$$\hat{r} = \frac{1}{3}\alpha + \frac{1}{3}. \tag{4.78}$$

(iii) In the credibility-constrained bonus scheme, the maximal credibly implementable effort level a^c depends on r and is defined by:

$$rB\left(a^c; \alpha\right) = \Pi^B\left(a^c; \alpha\right) \tag{4.79}$$

Plugging in $B(\cdot)$ and $\Pi^B(\cdot)$ as given in problem (4.VII), the condition becomes:

$$r \frac{9}{2} \frac{\left(a^c\right)^2}{3+\alpha} = a^c - \left(\frac{1}{2} + \frac{\alpha}{3+\alpha}\right)\left(a^c\right)^2 \tag{4.80}$$

Reformulation yields $a^c(\alpha, r)$ as given in equation (4.32):

$$a^c(\alpha, r) = \left(\frac{1}{2} + \frac{\alpha + 4.5r}{3+\alpha}\right)^{-1} = \left(1 + \frac{0.5\alpha + 4.5r - 1.5}{3+\alpha}\right)^{-1} \tag{4.81}$$

■

The implicit function $r^S(\alpha)$. Given the calculations above, the switching point is implicitly defined by:

$$\Pi^B\left(a^c\left(\alpha, r^S\right); \alpha\right) = \Pi^T\left(a_T^{**}(\alpha); \alpha\right) \tag{4.82}$$

From Figure 4.7, recall that for any $\alpha > 0$, there are two values of r^S for which the above equation is satisfied; one left-hand and one right-hand of the individual profit curve's maximum. However, only the larger of the two solutions is of interest as the smaller one undercuts $\hat{r}$ and, consequently, does not constitute a credibility restriction of the individual bonus scheme. Plugging in the profit functions from problems (4.VII) and (4.VI), equation (4.82) becomes:

$$a^c\left(\alpha, r^S\right) - \left(\frac{1}{2} + \frac{\alpha}{3+\alpha}\right)\left(a^c\left(\alpha, r^S\right)\right)^2 = a_T^{**} - \left(\frac{1}{2} + \frac{\alpha}{1+\alpha}\right)\left(a_T^{**}\right)^2 \tag{4.83}$$

Plugging in $a^c\left(\alpha, r^S\right)$ and a_T^{**} as given in equations (4.32) and (4.30), implicitly defines $r^S(\alpha)$. Explicitly solving equation (4.83) for $r^S(\alpha)$ yields two solutions, the larger (and thus relevant) of which is given by:

$$r^S(\alpha) = \frac{1}{9\alpha + 9}\left(3 + 14\alpha + 3\alpha^2 + 4\sqrt{\alpha(3+\alpha)(1+3\alpha)}\right) \tag{4.84}$$

Differentiating r^S with respect to α yields a cumbersome but clearly positive expression; i.e. $\dfrac{\partial r^S}{\partial \alpha} > 0$:

$$\frac{\partial r^S}{\partial \alpha} = \frac{\left(6 + 34\alpha + 18\alpha^2 + 6\alpha^3 + \sqrt{\alpha(3+\alpha)(1+3\alpha)}\,(11 + 6\alpha + 3\alpha^2)\right)}{9(1+\alpha)^2\sqrt{\alpha(3+\alpha)(1+3\alpha)}} \tag{4.85}$$

■

Chapter 5

Conclusion

This thesis was concerned with the impact of inequity aversion on the efficient design of incentive contracts used to mitigate moral-hazard problems under non-verifiable performance. Although the analyzed economic environments are, naturally, stylized representations of the reality, the findings provide some important insights regarding the suitability of the considered incentive schemes for the mitigation of moral hazard problems. Real-world institutions generally comprise multiple individuals and, moreover, involve at least some non-verifiable variables that are important to assess an individual's performance. My results underline that the agent's specific preference structure has important implications for the profitability and overall feasibility of relational incentive contracts. In particular, the impact of inequity aversion proves to be sensitive to the verifiability of the underlying performance measures. Moreover, my findings thus suggest that empirically observed cultural differences in social preferences should not be neglected in organizational decisions when firms rely on implicit incentives. For example, Corneo (2001) and Alesina et al. (2004) find Europeans to exhibit a higher propensity for inequity aversion than U.S.-Americans. Altogether, in contrast to the existing literature, my analysis shows that inequity aversion may be an advantageous factor in principal-agent relationships in the sense that it may alleviate credibility problems.

In three self-contained essays, I have analyzed and compared real-world incentive schemes that are of particular interest in the given context; individual, joint, and relative performance-pay schemes. The analysis highlights some important trade-offs regarding the agency costs that arise owing to the specific characteristics of these incentive regimes. In particular, joint performance-pay such as a group bonus contract excludes the possibility of unequal pay and thus avoids inequity premium costs completely. Due to a free-rider problem, such contracts, however, amplify the credibility problem. By contrast, relative incentive schemes such as rank-order tournaments solve the non-verifiability problem altogether. Yet, they necessarily create a high degree of income inequality between peers, which comes at the cost of large inequity premium payments. Unlike the two foregoing incentive devices, individual performance pay such as individual bonus contracts involve both agency costs due to inequity aversion and due to credibility problems, albeit to a smaller extent, respectively. Altogether, the agents' degree of inequity aversion and the principal's discount rate or, alternatively, the life span of the employment relationship, determine the relative profitability of the incentive regimes under consideration. The three studies of this thesis elaborate on the particular implications of the latter two attributes of principal-agent relationships under non-verifiable performance.

The first paper analyzes the overall impact of inequity aversion on relational individual bonus contracts. The study points out an interesting trade-off regarding the principal's credibility, which in turn determines the profitability and feasibility of the incentive scheme. Specifically, there are two counteracting effects at work: On the one hand, agency costs increase due to the presence of inequity aversion, and the principal's profits from the contract decrease as agents become more inequity averse. As a result, continuation of the relational contract becomes less attractive, and the principal's temptation to renege on the agreement increases. On the other hand, inequity aversion serves as an incentive-strengthening device. This implies that the principal has to pay a lower bonus to implement a given level of effort, thereby reducing her incentive to deviate from the contract. Whenever the former effect outweighs the latter, the presence of inequity averse preferences softens the principal's credibility constraint. My analysis shows that there are combinations of discount rates and inequity aversion, for which profits with more inequity averse indeed exceed those with less inequity averse ones. Moreover, for sufficiently small discount rates, reputational equilibria can only be sustained with inequity averse agents. Consequently, for a certain range of discount rates, the principal would rather employ inequity averse agents than purely selfish ones.

In the second paper, I introduce in a similar framework the possibility of group compensation and compare its advantage with the individual bonus scheme. In case performance measures are verifiable, the group scheme dominates the individual bonus contract as it completely avoids inequity premium costs. My study verifies, however, that this conclusion is reversed for a considerable range of discount rates once performance measures are not verifiable. This is due to two reasons: The group bonus scheme is subject to a free-rider problem requiring a higher incentive pay and impeding credibility of the firm. Moreover, with individual bonuses the firm benefits from the incentive-strengthening effect of inequity aversion, allowing for yet smaller incentive pay and facilitating credibility. Both of these features render the individual bonus contract superior for a range of sufficiently small discount rates.

The third paper provides some insights into the relative profitability of rank-order tournaments and individual bonus schemes under non-verifiable performance. When agents do not care about relative payoffs, the tournament clearly outperforms individual bonus contracts as the former incentive regime is contractible. I find, however, that this result is reversed for a considerable range of discount rates once agents are inequity averse. The result emerges from the fact that the tournament is then more costly than the bonus contract in terms of inequity premium payments. Thus, the latter incentive scheme dominates the former as long as credibility problems are not too severe. Moreover, my analysis suggests that the more inequity averse the agents are the more likely is an individual bonus scheme to be superior.

Concluding, it is worth pointing out that the results derived in this thesis have important implications not only for employment relationships but also for the design of institutions in general. For example, the presented research has emphasized that relational incentive contracts may successfully mitigate moral hazard problems even if an agent's performance is not verifiable by third parties. Moreover, such self-enforcing agreements are more efficient than tournaments when individuals are inequity averse. Typically, the members of an organization perform a number of tasks that are of great importance for the whole institution but can only be verified by e.g. a direct supervisor. In order to yet provide incentives for these tasks, organizations should thus include subjective performance assessments by the supervisors in their reward systems. Necessarily, the institutional structures of the organization must then concede some degree of discretion with respect to the evaluation of subordinates to the supervisors.

Further conclusions can be drawn regarding the design of societal institutions. For instance, a regulating agency should not neglect the prevailing preferences of the population. In particular, my analysis suggests that in case people are inequity averse, group incentives may yet implement the first-best efficient situation in two situations; either when performance measures are verifiable or when they are not verifiable but the firm's discount rate is sufficiently large. In addition, my results indicate that group reward schemes require larger incentive payments than individual reward systems. Now consider, for example, a progressive income tax. Such a tax system discriminates in favor of individual incentive payments, which might thus entail efficiency losses. Hence, the prevailing institutional design may possibly create significant distortions, given that individual preferences depart from purely selfish behavior.

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Berlin, den 28. Dezember 2008 Jenny Kragl